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WAR DEPARTMENT.

SIGNAL SERVICE NOTES.

No. I.

REPORT

ON

THE MICHIGAN FOREST FIRES

OF 1881.

PREPARED UNDER THE DIRECTION OF

BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,

CHIEF SIGNAL OFFICER OF THE ARMY.

BY

WILLIAM O. BAILEY,

SERGEANT, SIGNAL CORPS, U. S. ARMY.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF WAR

WASHINGTON:
OFFICE OF THE CHIEF SIGNAL OFFICER.
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THE MICHIGAN FOREST FIRES OF 1881.

The great Michigan forest fires of 1881 swept over four counties in three days, destroyed nearly two million dollars worth of property, and killed one hundred and twenty-five people. Their extent and irresistible power were largely due to atmospheric conditions, and they have, therefore, been considered worthy of description and explanation by the Signal Service. The data upon which this paper is based were gathered by Sergeant William O. Bailey, who is in charge of the station at the city of Port Huron, Michigan. Sergeant Bailey has gone over all the country visited by the fires, and has taken the testimony of many of the most intelligent of the survivors of the terrible disaster.

The summer of 1881 was excessively dry, and the drought had done its work nowhere more effectively than in the wide, blunt, tongue of land which lies between Saginaw bay and Lake Huron. At the northern end of this tongue is Huron county. South of Huron are the counties of Tuscola and Sanilac, the latter bordering on the lake. Lapeer county lies south partly of Tuscola and partly of Sanilac. These are the counties that suffered from the great fires.

In September no penetrating rain had fallen for almost two months. Almost every stream was dry. Many wells had become empty. The swamps had been burned to hard clay by the sun, fiercer in its heat than it had been for years before. The vegetation of the fields and woods had become tinder. The earth was baked and cracked, the heat having penetrated to an unusual depth. Ten years before, a great fire had burned over the country, and had left standing acres of dead timber, and the sapless trunks and dry branches made splendid food for the flames. Some of the old trees had blown down, and the forests were full of "wind-falls" and of great piles of dead timber which are called "slashings" by the people of the settlements. Everything was ready to feed the fires when they finally came. Old roots, pine tops, branches, brush heaps, timber, and the parched earth made the fuel for the burning.

In the early days of the hot, dry, August, forest and fallow fires were burning in almost every township in four counties. The farmers apparently took no thought of what might come from these usually harmless fires. They cleared their lands and burned their brush as they had always been accustomed to. Even then they had received warnings that ought to have been heeded. In the first part of the month, fires were raging in the woods near the village of West Branch, on the Mackinaw division of the Michigan Central railway. Lumber had been destroyed and railway trains had been impeded. The newspapers were beginning to announce that, in Tuscola county, large amounts of property had been destroyed, and even that life had been endangered. Notwithstanding the warnings, however, the farmers continued to start and feed the local fires. It was in August that the people of Tuscola first took alarm and began to fight the flames. The farmers of Huron and Sanilac, however, were evidently unconscious of the danger that threatened them, and on the first of September hundreds of local fires were still burning strongly all over the district.

The meteorological journal of the station at Port Huron announced on the thirteenth of August, the presence of "dense clouds of smoke from the forest fires," and that "large forest fires in the west and southwest are plainly visible from the station." The fires were beginning to be the question of the day, and apprehensions of disastrous results began to be entertained. Conflagrations were spreading in such a way that the people were forced to recognize what might happen. The flames had seized upon some of the "slashings" in Sanilac county. By the second of September, a conflagration had nearly destroyed Carsonville, and had burned houses, barns, and standing timber in the vicinity. At the same time the air was so filled with smoke that the sun was obscured, and the winds were dry.

The first important conflagration began on the thirty-first of August. The original fire had started in Lapeer county, and it spread northeastwardly, along the valley of the south branch of the Cass river, into Marlette, a township in the southwestern part of Sanilac county. The fire advanced northward, spreading through the centre of Marlette township. It traversed the forests as far north as Moore, then changed its course and spread in the direction of Custer and Watertown townships. It reached the village of Sandusky at about two o'clock in the afternoon. There it destroyed three buildings—a church, a school, and a dwelling. From Sandusky it went northeastward, raged through the swamps west of Black river, crossed that stream, and at four o'clock burned a part of the village of Deckerville. Thence the fire swept through the forests and "slashings" of Marion and Bridgehampton townships.

The wind changed to the north about dark, and, increasing in force, soon put out the flames. Before this, however, the conflagration had become general, and other villages than those mentioned had been threatened.

This fire was driven by strong, changing winds that grew to be gales as the flames advanced. The path of the fire through the village of Sandusky is shown on the accompanying diagram.

It was noticed, after the fire had passed, that the vegetation north of this path was fresh and green, while to the south every growing thing had been burned to the ground.

The spreading of the flames in Sanilac county was the direct result of the passage of a thunder-storm over the peninsula. This storm raged violently in the agricultural districts of Ontario during the afternoon of the thirty-first, and its southern quadrant extended as far as Port Huron.

The great conflagration started on its work of destruction on Monday, the fifth of September. It found the embers of the fire of Wednesday, the thirty-first of August, ready to be fanned into flames by the vigorous southwest winds that prevailed. Several days before this, fires had worked their way from the northern part of Tuscola county into the southern townships of Huron. By Sunday, the fourth, they had united and penetrated into the township of Colfax, and were burning in the forests west of the village of Bad Axe.

All day Sunday the wind was in the southwest, and was very hot. The village was threatened all night, and the next day toward noon the wind increased to a dangerous gale, changing to almost a west wind. The conflagration, as it approached the village, was apparently influenced by winds from two points, west by south and west by north, which, after a short struggle, were neutralized, and a powerful west current drove a storm of hot ashes and fiery cinders into and over the village. The fires did not enter the settlement directly, but circled in the air over the house-tops. It was twenty minutes only after the first building caught fire when the conflagration became general, and the people were seriously alarmed for their own safety. Within two hours all the houses in the village, except a few on the north and south, were

destroyed. The court-house, which is of brick, was saved, and four hundred people found refuge within it. The village stands in a small clearing, surrounded by a dense forest, in which were a large number of "slashings" and "wind-falls," the accumulations of many years.

Bad Axe village is in the township of Colfax. The fires burning in the woods on Sunday spread to the north and northeast into the townships of Meade and Chandler. Even on the fifth the settlers were clearing their lands with local fires. All this country had been burned over by the great fires of 1871, and there was a large accumulation of "slashings" and "wind-falls," especially in the southwest part of Chandler. For seventeen years this town had been full of lumber camps. The result was that there had accumulated from the trimming of trees, great piles of brush "pine tops," old knots, branches, etc. These, with the "slashings" and "wind-falls," furnished an abundance of fuel to feed a running fire.

The conflagration began spreading about noon of the fifth of September. Fresh to brisk west winds forced it across the line into the central and northern parts of Meade township. Here it met strong southwest currents. These swept it across the northwest corner of Lincoln and through the interior of Dwight into Port Austin, thence southeast through Huron, Gore, and Rubicon. Here a union was made with the conflagration spreading northeast from the head waters of the Cass river.

Through the townships of Meade and Dwight there prevailed before and during the fires strong southwest winds, with occasional changes to the west. This continued until three o'clock in the afternoon, when the wind suddenly changed to the north and blew a gale. Many of the inhabitants say that the wind changed into other quarters on Tuesday and Wednesday. On Monday, however, it fluctuated between the west and southwest until it finally changed into the north.

The conflagration spread very rapidly, burning down large, green, forests, and taking almost every farm house, barn, and granery that stood in its path. On section fifteen, in Meade, occurred the first destruction of life. In passing northward the fire touched only the western and northwestern parts of Lincoln township, where the soil is low, flat, and marshy. By one o'clock the fires began to spread north into Dwight township. The wind still blew from the southwest, with occasional shifts to the west, so that the fires kept moving toward the northeast. The fires broke through from Lake and Hume townships, about on a line with the lowest range of sections. These townships border on Saginaw bay, and the winds coming from the water toward the heated and rarefied air on shore, naturally held firmly in the west without any oscillations toward the southwest. Therefore the fires near the southern limits of Lake and Hume were held in check by the moist westerly winds, which were of sufficient force to drive the flames eastward into the township of Dwight. Here they were met by the more powerful and controlling southwest winds. As the flames increased and spread eastward into Hume, the destroying forces were increased, and, consequently, a larger number of buildings were destroyed than in Dwight, where the "slashings" and "wind-falls" were not numerous. The fires were driven back from Hume by the north wind about half past three o'clock.

One gentleman, who is vouched for by Sergeant Bailey as a very trustworthy man, says that the temperature in Huron, at seven o'clock in the morning, was ninety-nine degrees in the shade. This can be accounted for by the nearness of the forest fire and the direction of the wind; moreover, the thermometer was not properly exposed. The observation, however, is entitled to consideration as an indication of the true state of the atmosphere on the morning of the fifth of September. It was impossible to verify the reading of the thermometer, because very few of the people of the section possess or consult such an instrument.

The southwest gale that blew the fires into Huron township, was sufficiently strong to prostrate trees thirty feet high and six or eight inches in diameter, while young poplars, from six to nine feet high, were beaten down flat, or broken off about a foot from the roots.

The village of Port Austin, on Saginaw bay, was threatened from one to half-past three o'clock, when the wind changed to northerly. In these northern townships the north wind, which was a gale at first, continued to blow a fresh breeze all night. On Tuesday morning, the sixth, the wind changed to the west, and blew very hard all day until midnight, when it blew very hard from the southwest until four o'clock Wednesday morning.

The west wind which was blowing in Huron township at half-past one, increasing in force as it approached the centre of rarefaction, drove the conflagration to the eastward, and, shaping its direction to the outline of the coast, forced it across the northwest corner of Huron township, and into the village of Huron City. Here it became, literally, a whirlwind of fire, and raced through the whole length of the settlement. It penetrated the forests, and continued with terrible speed in the direction of Port Hope.

The southwest wind changed suddenly to the west, at half-past one, at Huron City, and ten minutes later the wind again changed a few points north of west and blew a gale. A black, ugly-looking, cloud, appeared in the northwest quarter, with detached fragments whirling about the centre. As this cloud advanced toward the village, darkness came on, and then the reflection of the conflagration in the direction of Grindstone village was seen. The western sky was splendidly illuminated, and revolving sheets of flame escaped from the woods and came, with almost lightning speed, in the direction of the village. The path of the fire was calculated to be between eighty and a hundred rods wide.

During the burning of Huron City the fires were spreading southward. They were accompanied by violent west of northwest winds as they moved down through Huron township. This was the general direction of the wind as the fires advanced from the north on the townships of Bloomfield and Rubicon. As the conflagration spread and the area of destruction grew larger, the atmospheric forces became more violent and vast sheets of flame were driven great distances through the air. By two o'clock the fires had reached the neighborhood of Port Hope, a village in the northern part of the township of Rubicon and on the shore of Lake Huron. A little after two o'clock the whole eastern front of the village, bordering on the shore, was in flames. At about half-past two the wind changed to the west, and the people began to congratulate themselves that what was left of their property would be saved, as the west winds would hold the flames toward the lake. Their hopes were short-lived, however; for there soon came a report that the whole western country was on fire. The village was saved by great exertions, but the danger continued to exist all the next day, and until the fires were extinguished by a heavy rain on Wednesday night.

The land about this village is undulating and prairie-like, and the soil is a fine, black loam, of good productive quality. South of the village, in the township of Rubicon, the damage caused by the fire was very great, for the flames had gathered strength as they advanced, and the gale had grown with the fires.

The whirlwind that carried the fire into and through Huron City, and thence southeast through the forests and into Port Hope, seems to have hugged the country adjoining the lake coast, and to have ultimately broken through to the lake somewhere in the neighborhood of the northeast quarter of the northwest quarter of section thirty-five. All the trees thrown down by the wind lay with their tops toward the south-southeast.

The country adjoining the lake shore is a low, flat, swale, and, before the fires came, it was covered with an undergrowth of young poplars, in the midst of which stood some dead timber, left after the fires of 1871. This swale does not rise more than one or two feet above the surface water of the lake, and it extends about a quarter of a mile back to a point where the land rises abruptly about thirty feet. On the high ground the land is rich and productive. In some places on the low-

land there were large groves of green timber. Before the fires these groves were so dense that the eye could not penetrate them more than eight or ten rods. Now, nothing is left but the dead, charred, and disfigured trunks of trees, some of them standing, but most of them thrown down.

The wind which accompanied this fire in its passage southward was strong enough to tear the roofs from barns, to throw down log-houses, to lift persons from the ground, and to hurl them short distances through the air. Toward the southern part of Rubicon, at the village of Forest Bay, an east-southeast current of wind was encountered. This struck a barn that had been unroofed by the west-northwest current, tore off a black ash rafter, thirty feet long, six inches square, and weighing, probably, two hundred pounds, and carried it ten rods. It was stopped by a board fence, under which it ploughed.

The fire-path is about twenty rods wide, and, although irregular, it is clearly defined, and shows where the fire broke through the forests a quarter of a mile to the west-northwest, and descended the steep hill to the edge of the swale,

While these northern fires were spreading to the northern limits of Sigel township, and to the northwestern limits of Sand Beach, which lie southwest and south of Rubicon, another conflagration had come up from the southeast, passed the head waters of the Cass river, and was spreading northeasterly.

This conflagration spread from the northern part of Tuscola county, and followed the course of the Cass river through the dense forests in Elkland and Novesta townships. It then swept over the highlands in Greenleaf and Sheridan townships, and then onward over Colfax, Bingham, Verona, Sigel, Austin, Argyle, Minden, Paris, and the western parts of Sherman and Sand Beach. The conflagration was the result of a union of the local fires, on the same days, (Sunday, the fourth, and Monday, the fifth of September,) on which the fires began to spread from west of the village of Bad Axe, in the town of Colfax.

The fires began to spread from the township of Elmwood. There was little loss here. The conflagration passed over the southeastern corner of Brookfield, in Huron county, and over all of Grant township except the northwestern corner. Colfax is directly northeast of Grant, and Sheridan is directly east. The fires spread northeastward and eastward through the forests in Colfax and Sheridan, and along the lowlands, both north and south of Cass river. The stream was bordered with forests of green trees, interspersed with the usual patches of standing dead timber. The green timber was chiefly soft wood. The "slashings" were, in many places, twelve and fifteen feet high, the heaped up "wind-falls" accumulated during ten years. The winds before and attending this conflagration were, like those that pushed on the fires from the neighborhood of Bad Axe, invariably from the southwest, and were very vigorous.

In moving toward tne lake, the fires followed the course of the two branches of the Cass river, which divide in the township of Novesta. That which followed the northern branch united with the conflagration, the course of which was first described. That which followed the southern branch joined the conflagration which was raging northward through the forests, swamps, and lowlands adjoining Black river. Thus, through the agency, among other things, of these water-courses, the fires were almost simultaneously sent forward from different quarters, and eventually united in a general conflagration which spread over an area of two thousand miles.

The fires surprised Cass City at about a quarter of twelve. At this time the local fires in the township of Novesta were rapidly merging into a conflagration, south of the Cass river. Scattered fires, both forest and fallow, were numerous throughout Novesta and the townships of Evergreen and Argyle, and thence eastward. The exact time of the breaking out of this conflagration is not known, but, as Cass City is distant only six or seven miles northeast of the western limits of the burned territory, it is inferred that the conflagration developed and started a little after eleven o'clock on the morning of the fifth.

The story of the fire at Cass City is like that which has been told of other fires. There were the same heat and darkness preceding the appearance of the flames, and there was the same strong southwest wind. The wind is said to have been so strong at this place that a man could not stand up against it. There was the same dryness—the dryness of soil, and streams, and wells—that the drought had made everywhere. Only one well in the village furnished water. The rain of Wednesday brought relief. Two houses and a few barns and fences near the limits of the settlement had been destroyed. The fires had passed over a ridge of green timber about a half mile from the settlement.

The land west of Cass river rises about twenty feet toward the village, while on the eastern side it is perfectly flat for many miles. At the forks of the two branches of Cass river the fires raged fiercely, thoroughly devastating much valuable farming property.

This conflagration, like the first, increased in vigor as it advanced. When it had reached Greenleaf, in Sanilac county, its growing magnitude was marked by the increased number of casualties. From there it was driven by the southwest winds, growing stronger all the time, over the townships of Austin and Bingham, to the east and northeast.

The fires reached the township of Argyle, east of Novesta, a little after two o'clock in the afternoon. The accompanying winds were west and southwest, but here we meet, for the first time, the story of a strong northwest gale, that blew fiercely for a few minutes during the burning of the fires.

Very much the same conditions prevailed in Bingham township, in Huron county, further to the northeast, on the northern branch of the Cass river. The northwest gale began to blow there, on section thirteen, at a few minutes past two. It was so strong that it lifted the roof from a barn and carried it about fifteen rods. Meanwhile the fires were burning in the forest toward the south and southwest. Shortly afterward the wind backed again into the southwest, and continued to blow with great force.

The fires reached Verona, directly north of Bingham, about three o'clock. The land throughout the region is a series of hills and ravines following the course of Willow creek to the north. The news of the conflagration which had begun at Bad Axe, and the course of which has been described, had been brought to Verona about two o'clock in the afternoon by persons who drove almost literally through the flames to reach their homes. Verona is directly east of Colfax, so that here the two conflagrations almost, if not quite, touched. The fire came on with the west-southwest gale. Before the flames reached the village there was total darkness, the smoke blotting out the daylight. The northwest gale here lasted fifteen or twenty minutes, and then the wind changed back to the southwest.

The land to the east and northeast of Verona is low, flat, and swampy, and the fires spread through these lowlands into Bloomfield township. They also spread over Sigel, which is east of Verona. They were so fierce and rapid in their work that whole villages were burned almost in an instant.

From Sigel the flames pushed eastward into Sand Beach. Monday morning had been very bright through this part of the state, and there were no signs of the approaching conflagration. At noon the people of Sand Beach noticed that the sky had become copper-colored. A little later it was red, and by two o'clock the darkness was so dense that people began to go about with lanterns. On Wednesday, the day on which the fires were extinguished, the wind changed to the north and blew from the lake.

The fires swept over Paris at about half-past two. They came from the west in a solid wall of flame fifty or a hundred feet high. It had been dark at noon, and to the intense darkness which spread over the country is attributed some of the loss of life. The sky was clear on Monday evening, but the fires continued to burn all day Tuesday.

The strength of the northwest current may be judged from the fact that, in Sherman township, it caught up a wagon weighing a thousand pounds, and hurled it fifteen rods across a railway track. There were here also indications of the presence of a strong northeast current.

On the north half of section fourteen and the south half of section eleven, an area a mile long escaped the flames, while southwest of this point twenty persons and almost all perishable property within a square of sixteen miles were burned. Here the opposing southwest and northwest winds met, and their struggle for supremacy created a roaring noise which was noticed with much alarm by all with whom Sergeant Bailey talked. The northwest current developed a superior strength and forced the fires toward the southeast across the northeastern corner of Minden village.

The struggle of the winds caused many vagaries of the flames. In the midst of the general destruction a shanty would be left untouched, or a gate would remain intact while the house, barns, granaries, and fence were destroyed. Northeast of Parisville the fires divided, and the property of some farmers was burned while that of others was untouched. At the Polish church in this village, a cluster of seven houses within an area eighty rods in diameter escaped, while everything outside this area was burned. On section seventeen, a rick of hay and a surrounding rail fence escaped destruction, while the owner's house, barn, stable, and fences were entirely destroyed. On the southeast quarter of section ten, a large house escaped, while a barn, ten feet to the northward burned. In some places fences on the west side of the road would be destroyed and fences opposite would escape.

The land is high, and, in some places, rises a good deal above the surrounding country, sloping toward the swamps in Paris and Bingham townships. At sections twenty-two and twenty-seven of Bingham township another ridge rises about forty feet above the lowlands. A broken series of these ridges extends in a direct line from Greenleaf township, through Austin, Bingham, and into Paris. The people call them "hog-backs." The soil is rich and productive, and many fine farms were situated on the "hog-backs." In Greenleaf, Austin, and Bingham the conflagration swept entirely over them, destroying almost every building. Those in Paris would undoubtedly have met the same fate had it not been for the timely change of wind into the northwest. On sections six and seven in Paris, and one and twelve in Bingham, there was conclusive evidence of powerful northwest currents. The forests, a dense growth of maple, pine, and hemlock, were badly burned, and the charred trunks of fallen trees rested invariably toward the southeast. Near the town line, at Smith's corners, two frame houses fronting the road escaped both wind and flame, while two barns only three or four rods toward the southwest were reduced to ashes. Westward from this locality, the swamps showed marked evidence of intense heat and strong winds. The young poplars were beaten down flat on the ground, facing the east and southeast, and, in some instances, were broken off short at the roots. Most of these escaped the fire, but the "cat-tails" were burned to the ground.

At Minden, the wind on Monday morning was in the southwest; toward noon it grew brisk, driving up clouds of smoke. Darkness came on about an hour later; the wind was then in the same quarter, blowing a gale. The conflagration was discovered in the forests, about two miles southeast of the village, about half-past three. At four o'clock the wind came like a flash of lightning, bringing the fire with it.

At this place the southwest wind tore off a part of a barn roof, and carried it a hundred rods. Another part of the same roof was caught by a northwest current, and hurled about a hundred and twenty rods into the summer fallow.

Like the other two, the southern conflagration was influenced altogether by southwest winds, changing to westerly as the flames approached the lake coast.

It started in Millington and Tuscola townships, and spread over Vassar and Indian Fields. Heavy fires had occurred in Fremont township on Thursday before the fifth, but it was not until the heavy southwest wind of Sunday arose, that danger was

feared. The wind increased in force on Monday, here as elsewhere, and drove the fires through the townships of the southern part of Tuscola county. Railway communication was broken at Cass, in the central part of Tuscola county, about two o'clock on Monday afternoon. The fires spread eastward through Watertown, Fremont, Kingston, and Koylton. In Lapeer county the conflagration swept through Burlington and Burnside. Then it entered Sanilac county, burned over Maple Valley township, Flynn, Elmer, Marlette, La Motte, Elk, Speaker, Worth, Lexington, Burt, Washington, Sanilac, Bridgehampton, and Marion. All Sanilac county had thus been visited by the different fires.

The rains of Wednesday extinguished all the fires, and the strong wind storm was over.

The course of all the fires, which together made the great conflagration, was mainly toward the northeast. How the fires ran racing over the four counties has been told, but the story gives no picture of the terrible fury of the storm of fire and wind, that destroyed the property and lives of the farmers and settlers.

The heat from the flames was so intense that the people felt it while the fires were miles away, and sailors at Forestville felt it uncomfortably at a distance of seven miles. It withered the leaves of trees two miles from its path. Whole fields of corn, potatoes, onions, and other growing vegetables that were not touched by the flames, were roasted by the heat. It even became the cause of an unnatural growth, and peach, apple, and other fruit trees burst forth in blossoms. Fish in the streams were killed by the fierce heat, and after the fires were over their dead bodies were found floating on the surface of the water Birds, escaping from these terrible flames, were carried far out into the lake, and, dazed and blinded, and finding no resting place, were drowned. Several witnesses gave an account of a curious phenomenon illustrating the intensity of the heat. A peculiar blue-white flame would sometimes burst forth from ignited tree stumps, flicker a few seconds, and then the strong winds would suddenly extinguish it. It resembled a lighted candle. Sergeant Bailey says: "Oxygen and carbon will ignite at a temperature of four hundred degrees, Centigrade, and, as the old tree stumps were badly charred by the fires of 1871, they were essentially a carbonaceous substance. The air was highly charged with gases, and, with the temperature raised to four hundred degrees or over, the causes of the phenomenon can, I think, be traced to these conditions." The phenomenon attracted attention in several places. Even the earth sometimes took fire.

The speed with which the flames and wind travelled, and the tremendous powers they exerted are almost incalcuable. Some of the effects of the wind have already been given. Large boulders were rolled along the ground as if they were pebbles. The conflagration is described as roaring like a tornado, and as giving forth loud explosive sounds, that were terrifying. As the storm advanced, it uprooted great trees, blew down buildings, carried roofs through the air, lifted men and women from their feet, and threw them back violently to the ground, in some cases seriously injuring them. The flames literally raced through the country, licking up villages almost in an instant. An anonymous writer says: "Dark and gloomy swamps, filled with pools of stagnant water, and the home for years of wild-cats, bears, and snakes, were struck and shriveled and burned almost in a flash. Over the parched meadows the flames ran faster than a horse could gallop." Horses did gallop before them, but were overtaken and left roasting on the ground.

Sometimes the flames were carried beyond buildings, and would then circle back and burn what had at first been spared. Sometimes everything for a mile would be burned, and then patches from ten feet to ten rods wide would be untouched. Here and there lanes hardly twenty feet wide would be burned, and a half-mile of fuel would be left on either side. The fire would run within three feet of a wheat stack, and would then glide away and burn a house. Its freaks were numerous and startling.

Before the fires came the air was thick with blinding smoke, and the darkness became almost total. In some places it was actually total. Lamps were lighted at midday, and the lights threw shadows as electric lights do. Through the darkness flaming balls of punk fell into the villages and fields, and then the fires would burst forth on every side. The flames came rushing on, sometimes in huge, revolving columns, then in detached fragments that were torn by the winds from the mass, and sent flying over the tops of trees for a quarter of a mile to be pushed down to the earth again. Flames were seen to leap many feet higher than tall pines, and everywhere over the burning country sheets of flame were flying in every direction.

The people of the four counties suffered as men and women have rarely suffered. Men, women, and children, old and young, were burned while they were flying along the public highway. The fires burned so intensely, and with such devouring force, that household articles were snatched by the flames, as their owners carried them into the air. Some of the fugitives were lifted from the ground by the strong wind, and were seized by the flames as they fell. Some saved their lives by scooping holes in the earth and burying their faces to escape suffocation, the fire, meanwhile, burning up their clothes and blistering their flesh. Others found refuge in wells, where they clung to the walls with fingers and toes, for twenty-four hours.

The flying sand and smoke blinded people, who walked, in the gathering darkness, into fire-traps. Those who escaped were blind for weeks. During the burning of the fires half-naked creatures made their way into village streets, often bearing the charred remains of the dead with them. Many found refuge from the fires in the lake, and even there they were suffocated by the smoke blown from the shores. The cinders, falling in the water, made a lye, so that it was necessary to go down several feet under the surface for drinking water. The remains of many of those who were burned were unrecognizable, so thoroughly did the fires do their work. Not only were the domestic animals killed, but wild beasts perished in the forests. They were tamed by fright, and herded with cattle and horses. One man who jumped for safety into the lake, found himself in the morning behind a bear, who was as submissive as a dog. Much sickness resulted from the disaster. Ordinary malarial fevers assumed a typhoid character, and serious lung and bronchial complaints were numerous for many weeks after the outbreak.

ATMOSPHERIC CONDITIONS.

The general atmospheric conditions prevailing during the fires were very favorable to their spread. The winds throughout the state, south of the conflagration, were generally from the southwest, while west and north of the fire-belt, a disturbing cause of sufficient magnitude produced violent and destructive air currents from the opposite quarter.

At Thornville, Lapeer county, about forty miles south of the conflagration, the wind blew at an estimated velocity of forty-five miles per hour, while the maximum heat was ninety-eight degrees. At Grand Haven, about eighteen miles to the westward, a southerly gale registered fifty-four miles per hour, and at Harrisville, Alcona county, the observer reported a southwest wind reaching an estimated velocity of thirty-five miles per hour, with clear weather. At Alpena, thirty miles north of Harrisville, and a distance of a hundred miles from the scene of the great fires there existed air currents from the opposite quarter, not, however, of so great velocity. The weather there was cloudy, and rain in all probability was falling not far from the station.

Conditions north of the burning territory strongly favored north to west winds, and while the fires were raging and generating abnormally high temperatures abnormally low temperatures prevailed only a few hundred miles to the west and north. It is stated that a cold northerly wind reached the burning district about three in the afternoon.

The geographical distance from Port Austin (Huron county) to Harrisville is forty miles, and to Alpena, seventy miles, in a northerly direction. At Harrisville, Mr. J. E. Fair reported that a southwest wind was blowing thirty-five miles (estimated) per hour at two o'clock. At Alpena the observer reported, at 2.34 p. m., a northwest wind blowing twelve miles (registered) per hour. The conflagration at this time was fully developed.

The wind in that locality must have changed between 2 and 2.34 p. m., and as the distance from Port Austin to the most distant station (Alpena) is seventy miles, its accelerated motion when it reached Port Austin, about three o'clock, can be imagined.

NATURAL CAUSES.

The natural causes and promoters of the conflagration, as has been indicated by this paper, are, therefore, as follows:

1st. Prevailing south to southwest winds for many days prior to the outbreak of the fires.

2d. A superabundance of hot air pushed northward by the prevailing winds from a locality reporting abnormally high temperatures.

3d. An area of low atmospheric pressure north of the fires, which was hedged in between two areas of high barometer, thus inducing a general circulation of air currents of opposite extremes of temperature.

4th. Opposing winds of unusual velocities south of the centre of lowest depression, and near the conflagration.

5th. A protracted drought during the months of July and August, a partial absence of rain and dew deposits during a period of from six to seven weeks, and, in many localities, no precipitation during that long interval.

6th. Soil dry, parched, and baked to such an extent, that, in many places, it was actually cracked open. Swamps sun-dried; grass, dry and withered; wells and cisterns, exhausted, and, in some places, no water for many miles from running streams to accommodate cattle stock.

LOCAL CAUSES.

The local causes of the conflagration were:

1st. Acres of dead timber left standing from former forest fires. Many "windfalls," "slashings," pine tops, and other inflammable material distributed over hundreds of miles.

2d. Carelessness of the settlers in the management of the hundreds of "local fires" burning over the territory.

The unprecedented spreading of the flames can, doubtless, be traced to the conditions spoken of in paragraphs three, four, and five, of natural causes in connection with those described as local causes.

SAGINAW
GENESEE
ARROW
GUILFORD.
FAIR GROUND.
T U S
DENMARK.
JUNIATA
TUSCOLA.
PASSAR
ARBELA.
THETFORD. FOREST.
G E N.

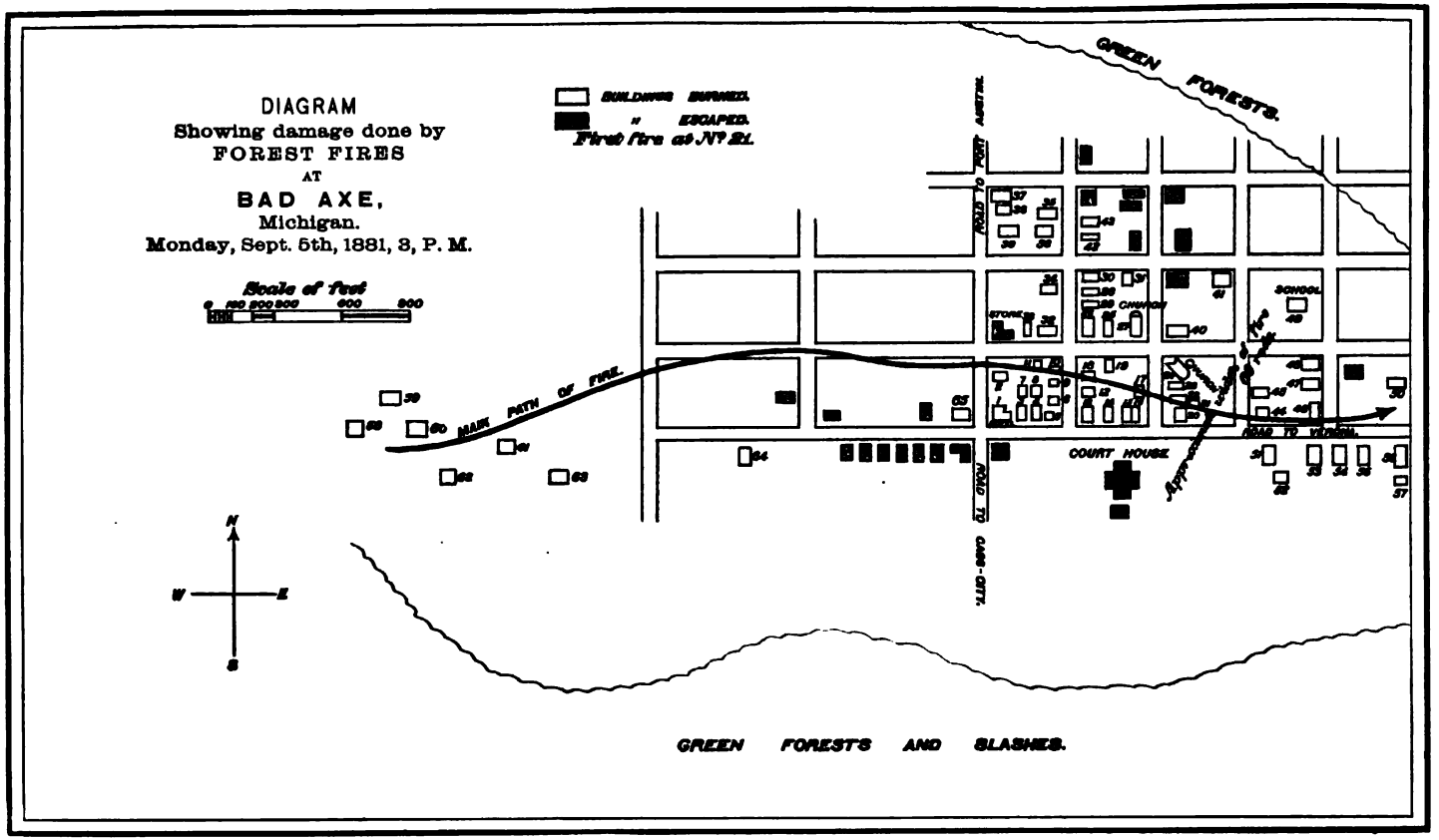


DIAGRAM
Showing damage done by
FOREST FIRES
AT
BAD AXE,
Michigan.
Monday, Sept. 5th, 1881, 3, P. M.
Scale of feet
0 100 200 300 600 900
BUILDINGS BURNED.
" ESCAPED.
First fire at N° 21.
GREEN FOREST'S.
MAIN PATH OF FIRE.
COURT HOUSE
ROAD TO GAGE-CITY.
ROAD TO VERONA.
SCHOOL
CHURCH
STORE
N
W
E
S
GREEN FOREST'S AND SLASHES.

DIAGRAM
OF
FOREST FIRES
AT
VERONA,
Michigan.
Monday, Sept. 5th, 1881, 3, P. M.

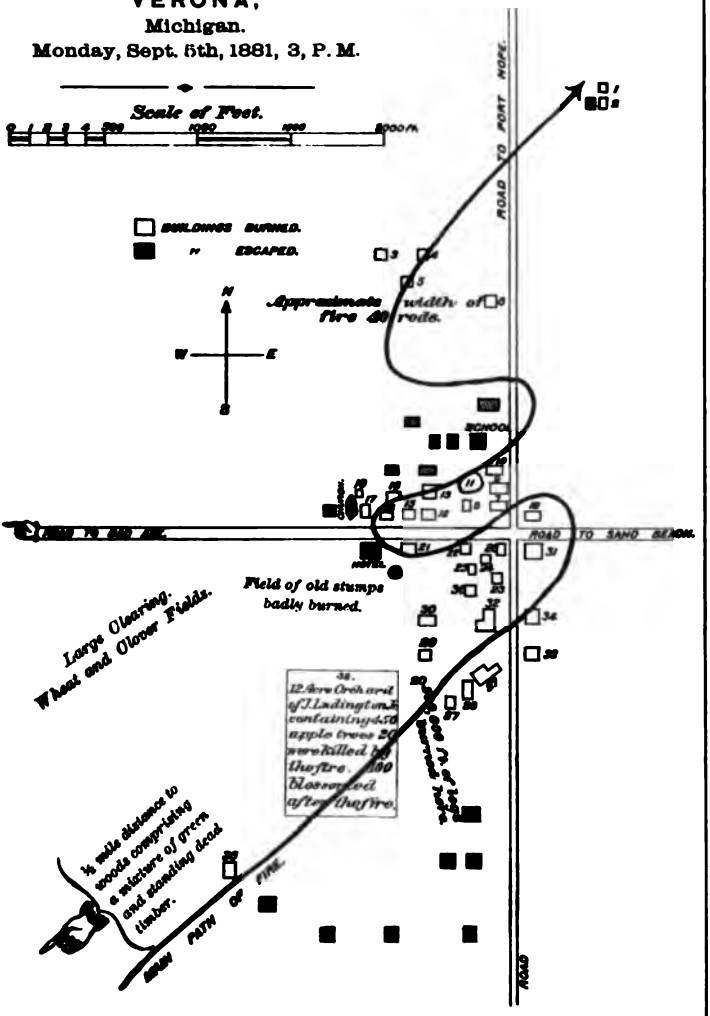
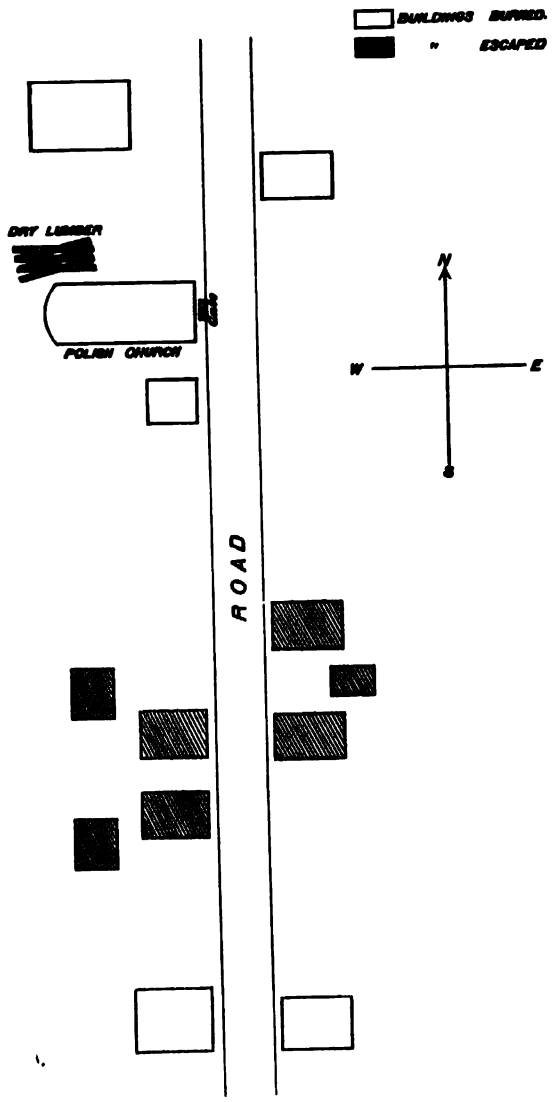

Scale of Feet.
BUILDINGS BURNED.
" ESCAPED.
N
W
E
S
Approximate width of fire 80 rods.
ROAD TO POINT HOPE.
SCHOOL
ROAD TO SAND BEACH.
Large Clearing. Wheat and Clover Fields.
Field of old stumps badly burned.
38.
12 Acre Orchard of J. Lindington containing 450 apple trees 200 were killed by the fire. 100 Blossomed after the fire.
½ mile distance to woods comprising a mixture of green and standing dead timber.
PATH OF FIRE.
ROAD

DIAGRAM
Showing position of houses
IN
SECTIONS 22 and 23,
PARIS TOWNSHIP,
Michigan.



DIAGRAM

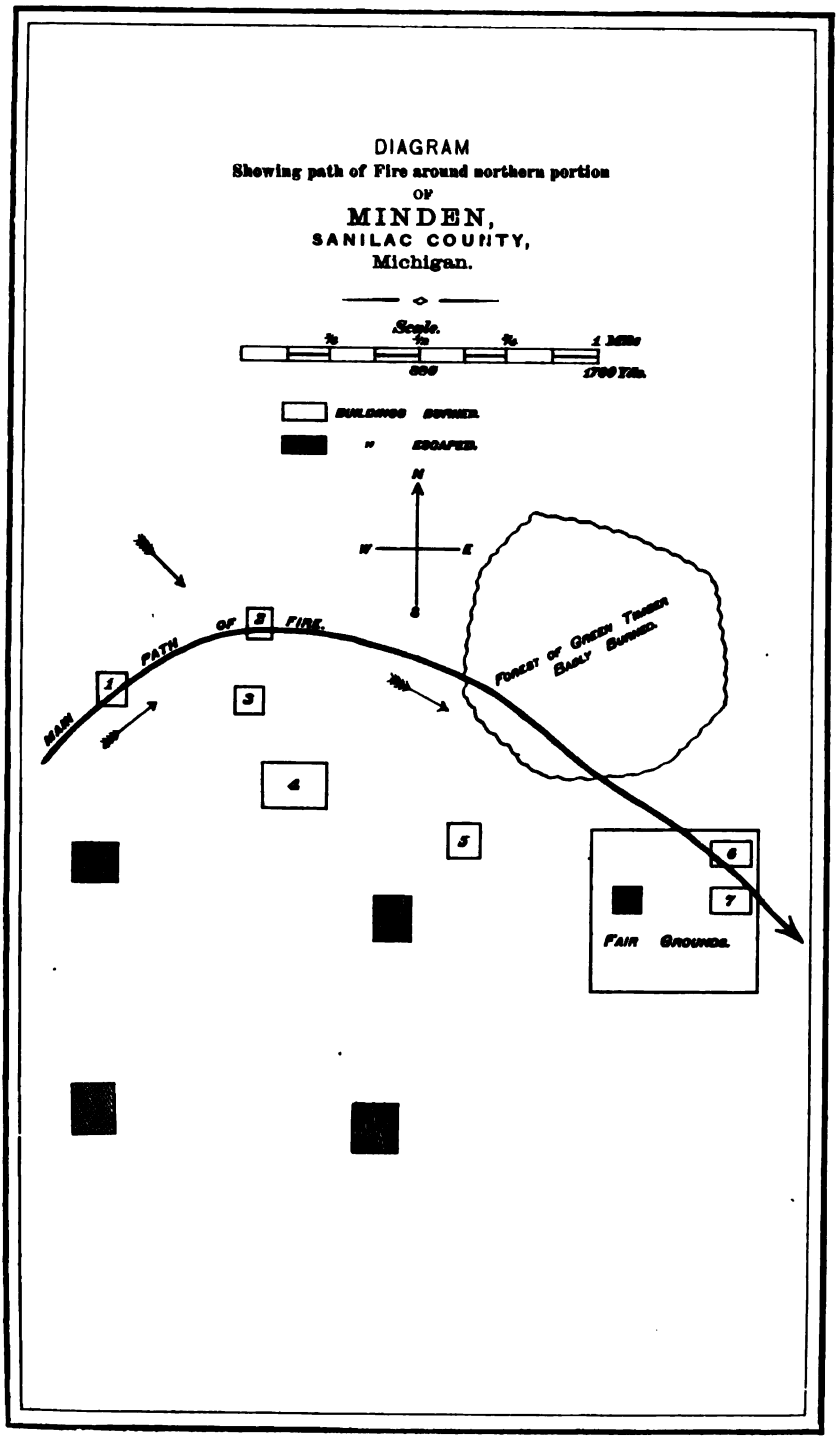
Showing path of Fire around northern portion

OF

MINDEN,

SANILAC COUNTY,

Michigan.



The following is a recapitulation of losses, with the latest directory report on population.

Settlement.			Population according to the last Directory (1880).	Number of—			Valuation of losses.
Township.	Village.	Hamlet.		Buildings destroyed.	Orchards destroyed.	Lives lost.	
(*Huron County.*)							
White Rock				0	0	0	0
Sherman				40	10	0	28,086
do		Adams Corners.	25	0	0	0	0
Sand Beach				12		3	4,343
do	Sand Beach		600	0	0	0	0
Rubicon				181	53	15	94,915
do		Forest Bay	50			0	
do	Port Hope		400	7		0	50,782
Gore				41	14	1	20,705
Huron				95		1	37,148
do	Huron City		75	21	2	0	60,000
Port Austin				3		0	800
do	Grindstone		250	0	0	0	0
do	Port Austin		800	0	0	0	0
Dwight				31		0	12,075
Hume				13		0	5,778
do	Port Crescent		300	0	0	0	0
Lake				3		0	1,164
Caseville				0	0	0	0
do	Caseville			0	0	0	0
do		Bayport		0	0	0	0
Fair Haven				0	0	0	0
do	Kilmanagh			0	0	0	0
Oliver				8		0	1,932
Colfax				22		0	9,161
Verona				96	14	0	76,881
do	Bad-Axe		400	70		0	70,831
do	Verona		150	32	2	0	70,400
Chandler				19		0	4,770
Meade				47		1	15,684
Lincoln				14		1	3,715
Bloomfield				88		8	35,203
Sigel				74		1	38,812
Paris		Parisville		446	123	22	279,382
do			60	0	0	0	0
Bingham				154		17	143,102
do	Tyre		150			0	
do		Ubley	50				
Sheridan				77	8	0	36,542
do		North Burns		0	0	0	0
Grant				9		0	2,441
do		Canboro		0	0	0	0
do	Kilkenny			0	0	0	0
Lebewaing				0	0	0	0
do	Lebewaing			0	0	0	0
Brookfield				10		0	2,886
Total			20,089	1,613		70	1,107,538
(*Sanilac County*)							
Greenleaf				166	62	0	71,524
Austin				185		5	121,259
do		Cumber	25			0	
Minden				81		4	51,805
do	Minden		200			0	
Delaware				216		8	94,422

Recapitulation—Continued.

Settlement.			Population according to the last Directory (1880).	Number of—			Valuation of losses.
Township.	Village.	Hamlet.		Buildings destroyed.	Orchards destroyed.	Lives lost.	
Delaware		Charleston	50	26	.....	.....	12,426 15,400
do	Forestville		350	0	0	0	0
Forester			.....	143	42	1	82,138
do	Forester		200	0	0	0	0
do	Richmondville		150	.....	.....	0	.....
Marion			.....	145	48	4	70,616
do	Deckerville		150	.....	.....	0	.....
Wheatland			.....	30	.....	7	13,444
Argyle			.....	41	.....	7	14,167
do		Argyle	50	.....	.....	0	.....
Evergreen			.....	32	.....	0	14,483
Lamotte			.....	17	.....	2	9,807
do		Lamotte	.....	.....	.....	0	.....
Moore			.....	72	.....	10	22,889
Custer			.....	8	.....	0	3,040
do	Sandusky		120	.....	.....	0	.....
Bridghampton			.....	19	.....	0	8,985
do	Farmers		100	.....	.....	0	.....
Sanilac			.....	35	.....	0	18,264
do	Port Sanilac		600	0	0	0	0
do		Pine Hill	75	0	0	0	0
Washington			.....	57	.....	0	23,220
do		Anderson	.....	12	.....	0	5,000
Watertown			.....	67	19	5	17,169
Elmer			.....	4	.....	0	2,001
do		Elmer	50	0	0	0	0
Marlette			.....	31	.....	0	20,680
do	Marlette		500	0	0	0	0
do		Germania	50	.....	.....	0	.....
Flynn			.....	7	.....	2	4,764
do		Omard	50	0	0	0	0
Elk			.....	77	.....	0	32,648
do	Peek		300	0	0	0	0
Buell			.....	27	.....	0	11,587
do		Buell	50	.....	.....	0	.....
Lexington			.....	14	.....	0	3,200
do	Croswell		600	0	0	0	0
do	Lexington		1,000	0	0	0	0
Worth			.....	.....	.....	0	.....
do	Amadore		100	.....	.....	0	.....
Fremont			.....	3	.....	0	1,656
do	Fremont		300	0	0	0	0
Speaker			.....	21	.....	0	8,192
do	Speaker		150	0	0	0	0
do		Melvin	70	.....	.....	0	.....
Maple Valley			.....	21	8	0	5,292
do	Beekit		250	0	0	0	0
Total			26,341	1,557	.....	55	$760,078
(*Tuscola County*)							
Geneva			.....	0	0	0	0
Wisner			.....	0	0	0	0
Akron			.....	0	0	0	0
do		Akron	50	0	0	0	0
Columbia			.....	0	0	0	0

Recapitulation—Continued.

Settlement.			Population according to the last Directory (1880).	Number of—			Valuation of losses.
Township.	Village.	Hamlet.		Buildings destroyed.	Orchards destroyed.	Lives lost.	
Columbia	Unionville		400	0	0	0	0
do		Columbia	25	0	0	0	0
Elmwood				12		0	5,422
do	Gagetown		300	0	0	0	0
do		Elmwood	50	0	0	0	0
Elkland				58	28	0	30,365
do	Cass City		400			0	
do		Elkland	50	0	0	0	
Novesta				60		0	22,054
do		Novesta	25			0	
Ellington				22		0	7,911
do		Ellington	70	0	0	0	0
Almer				4		0	2,093
Fair Grove				0	0	0	0
do		Fair Grove	50	0	0	0	0
Guilford				0	0	0	0
Denmark				0	0	0	0
Juniata				11		0	2,988
do	Watronsville		350	0	0	0	0
Indian Fields			0	3		0	1,230
do	Wajamega		100	0	0	0	0
Wells				11		0	3,022
Kingston				19		0	7,572
do		Kingston	85			0	
Koylton				6		0	5,256
Dayton				1		0	271
do	Dayton		300	0	0	0	0
Fremont				13	4	0	4,074
do	Mayville		150	0	0	0	0
Vassar				23	5	0	10,721
do	Vassar		1,600	0	0	0	0
Tuscola				1		0	271
do	Tuscola		600	0	0	0	0
Arbela				0	0	0	0
do		Elva	50	0	0	0	0
Millington				8		0	2,393
do	Millington		450			0	
Watertown				3		0	674
do		Watertown	50	0		0	0
Total			25,739	255		0	$106,317
(*Lapeer County.*) (North portion)							
Rich						0	
Burlington						0	1,616
do		Clifford	50			0	
Burnside				12		0	7,841
do	Burnside		125	0	0	0	0
do	Deanville		125	0	0	0	0
Total				12		0	$9,457

Recapitulation—Continued.

County.	Number of—			Valuation of losses.
	Buildings destroyed.	Orchards destroyed.	Lives lost.	
Huron County	1,613	.....	70	$1,107,538
Sanilac County	1,557	.....	55	760,078
Tuscola County	255	.....	0	106,317
Lapeer County	12	.....	0	9,457
Aggregate	3,437	.....	125	$1,983,390
Port Huron and Northwestern Railway Co's. losses.	.....	.....	.....	20,000
Grand total valuation of losses	3,437	.....	125	$2,003,390

Mat. 8

UNITED STATES OF AMERICA:
WAR DEPARTMENT.

SIGNAL SERVICE NOTES,
No. II.

MEMOIR

ON

THE USE OF HOMING PIGEONS

FOR MILITARY PURPOSES.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY.

BY

WILLIAM E. BIRKHIMER,
1ST LIEUTENANT, 3D ARTILLERY, ACTING SIGNAL OFFICER.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF WAR

C.
WASHINGTON:
OFFICE OF THE CHIEF SIGNAL OFFICER.
1882.

UNITED STATES OF AMERICA.— Signal service

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1882.

1884, Feb. 12.
Gift of
U. S. Signal Service Office.

NOTE.

It will be understood that the Chief Signal Officer is not responsible for any of the theories advanced by the author of this paper.

MEMOIR

ON THE USE OF

HOMING PIGEONS FOR MILITARY PURPOSES.

The result of the investigation into the practicability of using pigeons to carry messages in time of war is not so encouraging as was hoped. Although there are instances when they have been used to great advantage, and when they have been the only means of communication, there seem to be obstacles to their certain and systematic use in time of actual hostilities. It is a fact that, despite the greatest care in training, the pigeon sometimes fails at the critical moment. When it succeeds, however, the stake is generally very great. To attain one success it may be worth while to undergo many failures. For this reason, perhaps, those nations that devote most time and money to the perfecting of their military systems, still systematically train large numbers of pigeons for use in war.

It is proposed in this paper to give a brief historical sketch of the homing pigeon, the uses to which it has been put, and also some general ideas concerning its usefulness, from a military point of view, that may not be without interest.

The name, homing pigeon, is now given to birds that are trained to carry messages. The reason for this seems twofold: First, it is very expressive—the prominent and useful trait being implied in the name—*i. e.*, that the bird seeks its home; this is the trait that renders it valuable. Second, the name, carrier, is applied to a particular breed of pigeons—a class having particular characteristics—hence, to use the term carrier pigeon, to designate all pigeons that are used for the purpose of carrying messages, would lead to confusion. Although the name, carrier, is not entirely abandoned, it is not often used, and the name, homer, has about supplanted it.

The pigeon has been used for carrying from very early times, although the date of its first employment cannot be given. It is related that the victors in the Olympic games dispatched pigeons to convey to friends at home tidings of their triumph.

Pliny says that when Decimus Junius Brutus was besieged in Mutina (Modena) by Mark Antony, and the consuls Hirtius and Pansa, with Octavius, came to raise the siege—43 B. C.—Brutus communicated with the consuls by pigeons that flew over the heads of the besiegers. Commenting on this, Pliny says: "What service did Antony derive from his trenches and his vigilant blockade, and even from his nets stretched across the river, while the winged messenger was traversing the air?" And the fact that one great object of a blockade may be thereby defeated continues to make the use of pigeons popular, notwithstanding that each success may be attended by many disappointments.

It is well established that Nour-ed-deen Mahmoud, Mohammedan ruler of Syria and Egypt—1145 to 1174—had a regular pigeon postal service. From his residence, routes over which the birds flew, radiated to the farthest points of his dominions. Along these routes, at convenient distances, towers were built for watchmen, whose business it was to look out for the pigeons and care for them. No other ruler has

carried the use of the pigeon to such a systematic and high state of perfection as Nour-ed-deen.

It is said that when King Louis IX. invaded Egypt in 1249, his arrival at Damietta was made known to the Sultan at Cairo by a pigeon, so that Nour-ed-deen's successors were not unmindful of the lessons he had taught.

In 1573, at the siege of Haarlem, William of Orange sent a homing pigeon toward the city; it fell into the hands of the Spaniards, who, after that, tried to kill every bird flying over their camp.

It is said that during the years of the success of Napoleon I., Nathan Rothschild, of London, established pigeon-posts in France and some of the adjacent countries. By means of these pigeon-posts, the maintenance of which required many agents, he obtained information of the results of Napoleon's measures and campaigns, earlier than anyone else, and thus speculated intelligently and successfully. Afterward the idea was adopted by others, and regular pigeon-posts were established between Paris and Brussels and other cities. Bankers were thus informed of the fluctuations of the money market.

In the revolution of 1848, accounts of what happened at Paris were carried by the pigeons, and the messages they bore were published almost as quickly in the Belgian as in the Paris papers.

It will thus be seen that at this time the pigeon was beginning to play the part—imperfectly however—of the telegraph of to-day.

In 1849, a telegraph line was built between Berlin and Aix-la-Chapelle, but none from the latter place to Brussels; to fill this gap, Reuter had a pigeon-post established between Aix-la-Chapelle and Brussels, thus expediting communication by a saving of eight hours. Each telegram was forwarded by three pigeons to make reasonably certain the delivery of the message. This pigeon-post did much to establish the fame of Reuter's telegraphic bureau. The telegraph soon after this supplanted the pigeon-posts, as the railroads have supplanted the stage-coaches.

When Paris was about to be besieged in 1870, the pigeon-fanciers in that city suggested to the military authorities that the pigeons within the city limits be sent out, and that others from the provinces be sent into the city. The latter proposition was acted upon, but the former was not, until balloons were used, when there was an opportunity to send out pigeons in the balloons, it being intended that the birds should return with messages.

Pigeons had been declared contraband of war early in the Franco-Prussian war of 1870. There were taken out of Paris, in balloons, three hundred and sixty-three pigeons. Of this number, fifty-seven only returned. These bore letters, photographed in finest characters upon scraps of paper so minute that two hundred of them weighed only one-eighth of a grain. Newspapers, reduced by photography to microscopical characters, were carried by these pigeons. The magic-lantern was made use of to enlarge the letters, which, thrown upon a prepared surface, were read by the public. These fifty-seven birds were not the only ones sent into Paris during the siege. A pigeon-post service was established at Tours, for the purpose of conveying messages into the capital. The regular rates for this service made it possible for one bird to carry $500 worth of despatches, but, during the latter days of the siege, the Germans introduced trained hawks that were used to kill the pigeons.

These instances show sufficiently, that while the pigeon has been used for carrying messages, many causes—some understood and others not understood—unite to make them uncertain and untrustworthy means of communication.

The reason why the pigeon seeks its home, the fact that makes possible its use as a carrier, has never been satisfactorily given, and its discussion involves the most interesting inquiry concerning the bird. Some have believed the action of the bird due to instinct, others to training, while one of the most experienced and practical French fanciers has recently advanced the theory that the pigeon is guided in its

flight by currents of electricity in the air, or by other atmospheric influences; others, again, differing from all these, believe that instinct, intelligence, and careful training, combined, account for the action of the birds.

What is instinct? To this there may be many answers, but when considered in connection with the flight of birds, instinct is illustrated by the stork, which, traveling only at night, flies north in the spring and returns in the fall. Swallows and wild geese, and many other birds, move north and south at the same seasons. They do not, however, confine their movements to the night-time. All these move by what we term instinct. Whatever that may be, it is all-powerful in its influence on the birds. But it is not so with the homing pigeon. Experience shows that the flight of that bird is not certain unless it has been trained, and unless atmospheric conditions are favorable to its flight. Notwithstanding this, however, there are sometimes circumstances that give color to the theory that the bird flies by instinct alone.

One instance is cited, on good authority, when pigeons brought from Antwerp to London, returned to their homes, one hundred and eighty miles distant, without previous training. Birds have very often been carried seventy-five or a hundred miles from their homes, and, when released, have returned. It is very common, in training good birds, to make them fly from one station to another fifty or more miles apart. Now, how is it that the birds can find their way home under these conditions? They are carried in baskets, inside a car, so that it is impossible for them to see anything of the country through which they travel. No effort is made to enable them to see it. The explanation, it will be seen, is beset by difficulties. It cannot be instinct alone, for if there be a fog, or if snow covers the ground, or if it be night, the bird can do nothing. If an unerring instinct directs it, these natural circumstances would make no difference; the pigeon would return to its home. Nor can it be perceived how training alone can enable the pigeon to return. To assert this, is to say the bird sees its way home. This is actually asserted by some, but, it is believed, upon insufficient grounds. For instance, the fact that the pigeon when released usually circles round and round as he ascends, then darts off in the direction of home, is by some considered proof that he discerns some landmark by which to guide his flight. It cannot be pretended that the bird ascends until he can see one hundred and eighty miles. To do this it would be necessary (owing to the sphericity of the earth) that he should rise to the height of about seven thousand six hundred yards. Now, pigeons cannot ascend so high. The powers of those carried up to that altitude in balloons have been completely paralyzed, and when pitched into space the pigeons have fallen like stones through the air. It is also stated that pigeons released at a height of three hundred and twenty-five yards from the earth, or even at heights of eight hundred and fifty or eleven hundred yards, have not flown directly off, but, circling around lower and lower, have descended into apparently more congenial atmosphere before beginning their homeward journey. These facts seem to show that great altitudes are not suited for the voyages of pigeons, although they seem to ascend to them when first released, and before beginning their flight. To see sixty-two miles, the bird must ascend nine hundred and twenty-five yards; yet, when carried to that elevation and released, the pigeon immediately descends from it.

Mr. W. B. Tegetmeyer, the most experienced fancier in England, gives it as his opinion, that the homing faculty in pigeons depends solely upon observation and intelligence, as opposed to instinct. In his opinion pigeons fly by sight. If this be so, it may be asked why do not birds taken from Paris to the north return there as unerringly as they return from the south? Of several thousands sent north from that city by the military authorities, for homing practice, only a dozen or so returned. For this reason it is stated (with what truth is not known) that the training of pigeons at Paris for military purposes, toward the north, has been abandoned. In the failure here cited, Mr. Paul de la Rue, a celebrated French fancier, finds one of the strongest

confirmations of his theory, that the homing pigeon is guided by electrical currents, or by something analogous.

After carefully weighing all the arguments advanced by the various writers on this subject, it seems reasonable to suppose that the homing faculty of the pigeon is a combination of instinctive love of home, of sight, intelligence, and memory. The main-spring of its action is the love of home. This feeling exists in cows, horses, cats, and dogs, but it seems to be pre-eminent in the homing pigeon. It is by no means uncommon for the mental processes of those animals that are commonly supposed not to reason, to so nearly resemble reasoning that it is difficult to distinguish between them and the operations of the minds of confessedly reasoning beings. For example, a horse carrying his rider over the prairie comes to cross-roads; the rider is puzzled, does not know which road to take, and finally he permits the horse to choose; if they are returning home the horse will almost always take the right road. This is a very common experience on the great plains of the West, and the writer of this article can testify to the trustworthiness of the horse under such circumstances. It is believed that the faculties employed by the homing pigeon are similar to those exercised on these occasions by the horse—that is, a love of home and desire to reach it, the sense of sight, intelligence, and memory.

If this be so, it would seem proper that attention should be given to developing these faculties or senses in the homing pigeon. The higher they are developed, the more valuable will be the pigeon.

Recognizing the fact that the birds are improved by proper selection for breeding, and by subsequent training, no pains are spared by those whose business it is to raise homing pigeons for carrying purposes, to secure the best breeds, and to give the most careful training. The subject of the breeding of pigeons is foreign to the purposes of this paper, but the following remarks upon their training may be found interesting:

It is proper to remark that pigeons will fly only toward their homes. The popular idea that they will fly in any direction at command is fallacious and without foundation in fact. In Belgium, the land of homing pigeons, where the flying of birds is the great national sport, they are first flown, at the age of five or six months, five miles. This distance is regularly increased to one hundred and eighty miles, which is thought to be all they can well do the first year.

In England, pigeons, at the age of two or three months, fly one mile, then two, then four, &c., the distance being regularly increased.

Mr. Louis Offermans, of New York City, a veteran trainer both in Belgium and in this country, advises as follows for young birds: At three months of age loose them at a distance of three miles from home, at the cardinal points of the compass. He advises that, having done this, the bird be started in the direction in which it is to be flown. The bird should be flown every other day and the distance increased from three to six, from six to ten, and from ten to fourteen miles; then flights of twenty-four, thirty-six, and forty-eight miles should be successively undertaken, with three days between flights, and, after that, flights of seventy, one hundred, and one hundred and fifty miles, with an interval of one week; after three weeks' rest the season should be closed with a flight of two hundred miles.

For the second season, and for old birds, he advises as follows: Loose them three miles from home, at each of the cardinal points of the compass; then six miles; train in the direction whence it is desired the birds shall fly, first at twelve, then twenty-four miles, with one day's interval; rest them two days and send ninety miles; nine days later, two hundred miles; fourteen days later, two hundred and seventy-five miles; fourteen days later, three hundred and seventy-five miles; three weeks later, five hundred miles, thus closing the season.

It will be noticed that this plan of training confines the pigeon to the particular point of the compass whence it is desired that he should fly. This is for the purpose

of acquainting the bird with the path he is to travel. This idea is followed in training pigeons for military purposes at the garrisons in Europe. In Germany the pigeons are considered trustworthy for distances of from fifty to one hundred miles, if the breed of birds is good; if the birds are reared at the locality to which they are to fly, and if they are acquainted with the country over which they are to travel.

A flight of thirty miles an hour, sustained for any length of time, is extraordinary, though, for short distances, pigeons have flown faster than a mile a minute.

The following table gives a summary of races, selected at random, in 1874 and 1875, in France and Belgium:

1874.	Yards per minute.	Miles per hour.	1875.	Yards per minute.	Miles per hour.
June 7	860	29¼	May 30	699	23¾
" 14	831	28½	June 6	1,531	52¼
" 14	1,383	47¼	" 13	1,531	52¼
" 21	853	29	" 20	1,476	50¼
" 28	1,208	41¼	" 27	1,208	41¼

To still better illustrate the average flight of birds, twenty-one flights were taken. The time of the flights over the same distance varied from three to eight hours, the distance per minute varying from eight hundred and fifty-eight to seventeen hundred and eighty yards, the latter rate having been sustained for four and three-fourths hours.

In England, two hundred miles at a race is seldom exceeded. In Belgium, the distance flown in the racing season by old birds ranges from two hundred to five hundred miles. At the grand race of 1868, of five hundred miles, fifteen hundred and seven birds were entered. The prize bird flew the distance in twenty-five hours, an average speed of twenty miles an hour. This bird did not fly the twenty-five hours continuously, but, as is the custom of the pigeon, came down a little before dark and started again soon after daybreak, meanwhile securing food.

Atmospheric conditions exert a strong influence on the flight of pigeons. Birds of the best breed, full-grown and well-trained, will fly five hundred miles in twelve hours in favorable weather, but in bad weather the same birds will take two or three days to make the same distance, and often they cannot fly at all.

In the United States, the first attempt to fly pigeons five hundred miles was in 1878, from Columbus, Ohio, to New York City. The birds were never heard of after they were started. Next year (1879) the attempt was repeated with six birds; they were released July 27th and two of them arrived in New York the next day.

On June 12, 1881, some New York City birds were loosened at Cresson, Pennsylvania, the distance being two hundred and forty-three miles. The day was clear, the wind contrary, and the time of flight of the winner was four hundred and thirty-three minutes, or an average of nine hundred and eighty-eight yards a minute. On June 14th, with a favorable wind and foggy, cloudy, weather, with occasional sudden and severe thunder-storms, the winner passed over this same course at the rate of twelve hundred and ninety-six yards a minute. The birds are generally practiced over this course by easy stages and, therefore, they are very familiar with the country.

On June 28, 1878, the New York pigeons were flown from Steubenville, Ohio, three hundred and forty-one miles. The winner made the distance home in eight hours and eighteen minutes, or at the rate of twelve hundred and five yards a minute.

In 1868, the experiment of flying birds from Rome, Italy, into Belgium, was tried. The distance is nine hundred miles. Five hundred miles of this country was unknown to the birds. Of the two hundred loosened but twenty returned, the shortest time made being thirteen and one-half days. As the Alps stood in the line of flight, and as the birds must have flown around the mountains, it is a wonder that any of

them returned. It is doubtful if this experiment did any good. It proved, indeed, that the homing pigeon is endowed to a wonderful degree with the faculty, whatever it is, which directs its flight toward home, but that only one pigeon of ten returned to its loft is certainly not encouraging.

In Europe the homing pigeon is carefully bred and trained, with a view of perfecting its good qualities. There are many societies in Belgium and France for training pigeons for the annual races, which are a national pastime in each country. As may be supposed, this training is attended with trouble and expense. One plan is this: A man is sent with the baskets containing the birds; he feeds them, looks out for their welfare, and releases them at the proper time, and in the proper manner. Another plan is to send the pigeons, properly labeled, in care of the express and station agents, who attend to the wants and flight of the birds. The first plan is the more expensive, but it has so many advantages that it is generally resorted to in important cases, and generally when the owners of the pigeons can afford the expense.

There are many societies in the United States devoted to the raising and training of the homing pigeon. They constitute the "Federation of Homing Pigeon Societies of the United States." Among these are, "The Red Star Pigeon Club," of Philadelphia, Pennsylvania; "The Albany County Homing Club," of New York; "The New York Homing Pigeon Club;" and "The Old Dominion Homing Pigeon Club," of Alexandria, Virginia.

In addition to the work done by civil societies, many European governments train pigeons for military purposes. The Russian Minister of War has ordered the expenditure of $10,000 for pigeon training in Warsaw and Kieff alone. Large numbers of homers are kept and systematically trained at both places. Several officers have become very expert in the management of the birds, and two have lately been especially honored for their energy, and for arranging rules for the employment of pigeons during war. In Germany and France, also, the training of pigeons for military purposes is carried on. Pigeons are also used in Turkey. In fact, all nations of Europe seem to recognize that homing pigeons can be used advantageously in war, and all, in greater or less degree, devote time and money to keeping their pigeons in training and to improving their stock.

In the United States, so far as the writer is aware, there has been but one experiment with pigeons made under the patronage of government officials. In 1878, the Signal office purchased some pigeons of Mr. Thomas Gist, Philadelphia, Pennsylvania, and sent them to Colonel Nelson Miles, 5th Infantry, in Dakota. Colonel Miles tried to train and use the birds, but without success. This was doubtless due to many causes. The birds might not have been of the best and most trustworthy breeds; the trainer may not have been conversant with his duties; the systematic exercise of the pigeons may have been either neglected or improperly carried on. Either of these causes would prove fatal to success. In addition to these possible drawbacks, Colonel Miles speaks of a species of hawk, common to that region, which most persistently hunted down the pigeons, in many cases killing them before they could regain their lofts.

It may be considered as an established fact that the military authorities in the United States will not devote either time or money to extensive experiments with homing pigeons until it can be made more apparent that the birds can be advantageously employed. The most inviting field for action would be the Indian country of the west; yet it is extremely doubtful if the best breed of the birds would be so useful as to compensate for the trouble of training and caring for them. That they may be of practical use it is necessary that the birds be of the finest strain; that they be carefully and systematically trained; and that they become acquainted with the ground over which they fly. Take the best bird into the Indian country, establish a loft at one of our military posts, then, without previously train-

ing him, carry the pigeon a hundred miles into the mountains or bad-lands, and turn him loose; the chances are very great that he will never be heard of again. It will be readily understood that it will be impossible to give the pigeons the careful and elaborate training that fanciers assert is necessary. It may be assumed that no occasion will arise when soldiers in a hostile country will not have enough to do without carrying pigeons distances of from five to fifty miles for training purposes.

The plan now recommended by fanciers who have given the subject study is, that each bird be trained in the direction in which he is to fly; then he will know the country. It is impossible to rely upon such a system in our Indian country. How can a scouting party, starting out toward the north, know but that the next day they will be a hundred miles south of their post? If they had taken their pigeons trained only for flight from the north, of what service could they be? In one word, so far as the the writer of this paper can judge, there is no benefit to be derived from training pigeons in the Indian country at all commensurate with the trouble, the labor, and expense involved. Along the sea-board, and in the interior, excluding the Indian country, it is different. In most of the cities of the sea-board there are many birds that could be procured for training for military purposes, and the rail-roads and steamboats afford facilities for training.

No branch of the army is so well equipped for this kind of work as the Signal Service. Its agents are scattered at reasonably short intervals all over the interior and along the sea-board. They are intelligent men, and would serve admirably in the necessary office of custodians for the pigeons, and would see that they were properly taken care of and properly flown.

After the views expressed above as to the questionable utility of pigeons for carrying purposes in time of war, it seems unnecessary to present a detailed plan for a military pigeon-service. If one be desired, however, the demand can be complied with.

All of which is respectfully submitted.

WM. E. BIRKHIMER,
1st Lieutenant, 3d Artillery,
Acting Signal Officer.

MAY 13, 1882.

NOTE.—The following memoir, treating the subject of the training, habits, care, and breeding of homing pigeons, printed at the Headquarters of the Military Division of the Pacific, 1882, is, by permission, reprinted in connection with the foregoing report of Lieutenant Birkhimer:

PIGEONS AS COURIERS IN THE MILITARY SERVICE.

Pigeons, as carriers of messages, are habitually used in many places with great success.* For a distance of two hundred miles they travel as fast as the mail by steam, and through hostile country will return to their destination more certainly than most men. They fly by sight, and can therefore be used with greatest advantage in a region where there are prominent mountain peaks, few storms, and where the air is clear, and where snow rarely covers the ground and the mountain tops to change the natural aspect of the country.

The important occasion for their use by the military is to keep up communication between two such posts as Forts Apache and Thomas, or between Fort Thomas and San Carlos, when the telegraph, entirely through hostile country, is broken, and

*Country physicians in England make use of the pigeon with great advantage, leaving them with the distant families whom they visit to be sent off with a message when their services are needed.

when the intervening streams are flooded, and interrupt all travel for days; also, when on detached service in a hostile country, and distant from any telegraph and out of sight of any heliograph station, to convey important information, make known great need, and call for assistance. In Arizona these occasions will probably occur more frequently now than heretofore, as our troops, by an international agreement, are authorized to cross the borders of Mexico in pursuit of hostile Indians.

It is true that the pigeon only carries a message "home," and this only after having been trained; that they only fly during the day, and when the air is clear so that they can see a long distance; that they cannot be relied upon when snow covers the ground, or if overtaken by a storm; that they require the careful attention of one man who will learn to know them by sight, who will keep them properly numbered, and keep a correct record of the pedigree and journeys of each bird under his charge. All this requires strict attention and gives trouble.

But their cost, trouble, and expense will be insignificant compared to the benefit they will confer by conveying important information at critical times.

The posts in Arizona where pigeons could probably be used to most advantage at first are Grant and Huachuca. As these posts will have large garrisons they will be the first from which expeditions start; at these large posts some one will probably always be found with a special aptitude and fondness for breeding and training pigeons; and being near the railroad, the birds can readily be sent to increased distances while in training.

The new post near the southern border of Arizona, on the Chiricauha range, when established and in communication with Department Headquarters by the military telegraph system, will be another station at which the pigeon may be expected to render important service. Anyone with the least fondness for natural history, or of games in which competitive effort enters, cannot but become deeply interested in the breeding and training of pigeons, and in their wonderful voyages; and the voyager so strong of wing and enduring as to be the first to bring from a long distance, across a trackless, hostile country, in a few hours, the news of a victory or a call for help from those in whose fate many interests attach, cannot but be accorded military recognition and a place in military annals.

Two interesting letters just received, one from General Miles, the other from Mr. J. H. D. Smoot, of Alexandria, Virginia, addressed to Major Breckinridge, Assistant Inspector General, are here inserted. Mr. Smoot offers most important suggestions in regard to the whole subject of breeding, feeding, marking, training, and flying the homing pigeon. It will be observed that both writers refer to the fact that use of the pigeon has already engaged the attention of the Signal Service.

PORT TOWNSEND, W. T., *August* 5, 1882.

MAJOR J. C. BRECKINRIDGE,
Presidio of San Francisco, California.

DEAR MAJOR: Referring to your letter of July 18th, ultimo, regarding my experiments in the Northwest with homing pigeons, I would state that in 1879 I received, through the Chief Signal Officer of the Army, twelve pigeons,—strong, hardy birds, very tractable, and, as far as experimented with, their action was very satisfactory.

They bred rapidly, and, when I left Fort Keogh, numbered about fifty.

At times, when flying them, we were troubled by a small hawk, which greatly disturbed the birds in their flight, occasionally destroying them.

My experiments were successful, and demonstrated the fact that they can be made useful for military service.

The longest distance made was about one hundred miles, from the mouth of the Big Horn River to Fort Keogh, Montana; but they only had a few trials, and were not fairly trained. When in Montana I was unable, through want of time, to make as thorough an investigation as I should have desired.

* * * * * * *

I believe that by securing the best class of birds, and with proper care and training, they can be made quite useful.

Very respectfully,

NELSON A. MILES,
Brigadier General, U. S. A.

ALEXANDRIA, VIRGINIA, *July* 24, 1882.

MAJOR J. C. BRECKINRIDGE.

* * * * * * *

It has been with me, for several years, a pet project to introduce him in the Army, for I know he can be made a powerful agent in the hands of those who will learn how to use him, which can only be by actual experience.

On June 17, 1882, I had three birds to come home, in six hours and forty-five minutes, two hundred and thirty-three miles, air-line.

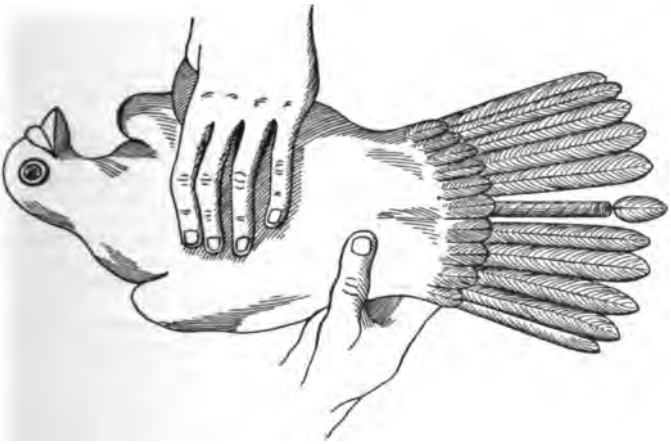
On July 15th, eight birds were liberated at Northampton, Massachusetts, three hundred and forty miles air-line from Alexandria, at 8:20 a. m.; the first was home at 6:20 a. m., the 16th, and two more at 7 a. m.; on the 17th, one at 4 p. m., and on the 18th three at home by 6 p. m., but one out of the eight not returning.

Some time last winter I had a visit from Lieutenant W. E. Birkhimer, from the Chief Signal Office in Washington, asking information as to this bird, he having been ordered by General Hazen to report upon their utility for Army service.

The clear atmosphere of Arizona is just the place for these birds, and they can there be depended upon with a great deal of certainty for two hundred or three hundred miles in ten or twelve hours flying time.

Message. Middle tail feather of homer.

The message should be adjusted to the middle feather of the tail, first shaving both sides to within an inch of the end; then lash the message, with waxed silk, firmly, so that the bird cannot peck it off. One person must hold the bird to prevent it from fluttering while another attaches the message. Messages



Manner of holding pigeon when attaching message.

should be written with lead pencil (ink runs if wet) on very fine tissue or manifold paper, and folded very tight. Messages should be sent off on several birds, and if of very great importance, on ten or fifteen, so that some will be sure to reach the fort.

The message on the middle feather of the tail will not annoy the bird, for when he is at rest it folds on top. Do not tie message on legs, as it is necessary for the bird, in flying, to hide the feet in the breast feathers so as not to offer resistance to the air.

John Van Opstal, No. 4, Louis street, New York, is the best breeder of this bird, and knows more about them than any man in America.

Jos. B. Hasson, 360 W. 59th street, New York; E. O. Damon, Northampton, Massachusetts; Wm. Verrinder, Jersey City, New Jersey; Thomas H. Richardson, Green Island, Albany County, New York; F. Peters, Troy, New York; E. J. Bramhall, 289 President street, Brooklyn, New York; F. Whitely and A. P. Baldwin, Newark, New Jersey; and Henry Green, Alexandria, Virginia, are all reliable gentlemen, and have first rate stock.

The books to consult are "The Homing or Carrier Pigeon," by W. B. Tegetmeier; "Dr. Chapins on the Homing Pigeon" (in French). These books can be had at the office of the "Homing Pigeon," 78 Cortlandt street, New York City. Everyone should subscribe to this paper, as it is full of valuable information It is published by Mrs. E. S. Starr, who is fully posted upon pigeon lore; price, $1.50 per year.

FOOD OF THE HOMER.

Corn, wheat, buckwheat, oats, barley, rye, and peas are good food, and should be given mixed; also millet, or, in fact, any kind of grain is acceptable to them, and they, like man, thrive best on a variety.

The food and water should always be given in the loft, so that the birds, when coming from a voyage, will immediately go into the coop, where the message can be quickly gotten.

In the loft of the homer there should be a lump of rock salt, broken salmon brick, or burnt clay where brick cannot be had, old mortar to furnish lime for egg shell, or the shell of hen's eggs roasted or pounded, or slacked lime, gravel, and sand.

BREEDING HOME AND ESTABLISHING MILITARY LOFTS FOR THEM.

Select ten pairs of birds from as many different lofts, so that they may be as distant in kin as possible, and cross match them. For the terrible ordeal they have to undergo they should be as strong as possible and they degenerate rapidly by in-and-in breeding. I do not breed my birds nearer in kin than second or third cousins, hence my success in long-distance flights.

TO DOMESTICATE OLD HOMERS TO A NEW HOME.

This, to the uninitiated, is quite a difficult matter, but I have had success by following the method of taking ten of the long feathers of one wing and sewing them together with a strong thread, which will make the bird lop-sided and prevent flying. After they have young, cut the wing of the cock loose, and he will most probably stay; then, at the end of a week, treat the hen in the same way. Old birds cannot be trusted on a voyage, as they too often try to hunt their old home, and thus become lost. The young, when ninety days out of the egg, are good for sixty miles; and at six months I have known them to come 300 miles air-line.

COT FOR HOMERS.

The cot for homers should be eight feet high, ten feet wide, twenty feet long, with a slatted partition that can be swung up to the ceiling when not in use, to separate the cocks from the hens during the fall and winter. The nesting places should not be above the level of the eye, and no place for the birds to rest should be higher than five and one-half feet, so they can be easily caught. All droppings should be removed daily, and Italian insect powders be freely used on the young to keep down vermin. At the age of twenty days the young should be branded with a number and registered in a book for that purpose, stating the number of the parents, so that the pedigree may be kept to prevent mating too close kin. Use a *pure* tin tag around the leg, with number stamped thereon. I send sample of leg tag.

TRAINING.

Birds should be trained in one direction only, and this should be done as soon as they have been flying out three weeks. First send them five miles; two days after, ten miles; and in three days send them fifteen miles; again in three days, twenty-five miles; in five days, forty miles; thereafter in five days, sixty miles; then in five days, eighty miles; seven days, one hundred and twenty miles; seven days, one hundred and eighty miles; seven days, two hundred and fifty miles; seven days, three hundred and fifty miles—all in the same general direction. Never take a bird off his course; better have four lots trained from as many different points of the compass. A bird that is trained to find home by flying from the north to the south, if taken to the south will not hunt home to the north, but will fly south and be lost. When training birds from different points, paint the two wings with oil colors—blue for those sent north and yellow for those that fly from the south, and by this means a mistake will seldom be made in sending birds in the wrong direction.

Birds should not be sent more than 150 miles the year they are raised, and that not before the first of October, for they have not sufficient endurance before that time.

If I had the management of this bird for Army purpose I should, at a post from which scouting parties were likely to be sent out in all directions, have at least four lots, trained from as many points of the compass, so from whatever direction a scouting party was required to send information to the fort I should have at least one lot that could be sent along to make the trip. On very important occasions it would be well to also start couriers at the same time and not rely wholly upon the birds.

A bird that has flown from 100 miles will come better from 150 than he would from an intermediate place only 75 miles from home; always keep sending him from a place further on; never fly him, as we call it, backwards, unless it has been at least twelve months since the bird has been on a voyage.

It matters not how good the stock, there will always be some poor ones bred that do not seem to have the faculty of knowing which direction is their home, and will often fly directly opposite and are lost.

Should you conclude to buy birds in the East it will give me pleasure to present a few pairs of my young out of my long distance stock, which, I think, is as good as any in this country or Europe, and will cheerfully aid you in selecting birds from reliable gentlemen.

Birds purchased here would require the care of a conveyor to California, as they would never reach you alive without some one to look after them during so long a journey.

I am, very truly, yours,

J. H. D. SMOOT.

EXTRACTS FROM W. B. TEGETMEIER'S TREATISE ON HOMING PIGEONS.

PIGEON-HOUSES.

Pigeons are usually kept either in pigeon-houses or in lofts or rooms specially devoted to the purpose. A pigeon-house on a pole may possibly be regarded as a picturesque addition to a farm or stable yard, but a worse residence for the birds it would be almost impossible to devise. The pigeons in these houses are exposed to all the variations of the weather. During the great heat of summer the close nests become offensive, from the accumulation of dung, and swarm with vermin. In the cold weather the young birds frequently perish from the low temperature to which they are exposed, and at all seasons of the year the driving rain is apt to saturate the nests and destroy the vitality of the eggs or the life of the unfledged birds. It is obvious that a pigeon-house can only afford comfortable breeding quarters during a small proportion of the year; and in inclement seasons is a dreary habitation even for full grown birds. The result of these disadvantages is, that the same number of birds will not rear half the number of young in an exposed pigeon-house that they would if placed in a comfortable, well sheltered loft or room.

If pigeon-houses are employed at all, they should always have a broad roof, projecting far over the sides, so as to screen off the rain as far as possible. Houses on poles are worse even than lockers placed against a wall, as being less sheltered, and offering the smallest amount of accommodation for the inmates.

The following plan for their improvement has been proposed by E. S. Delamer, who writes:

"The best pole-house is that of which a plan and elevation are given in the accompanying cuts. (See Fig. I.)

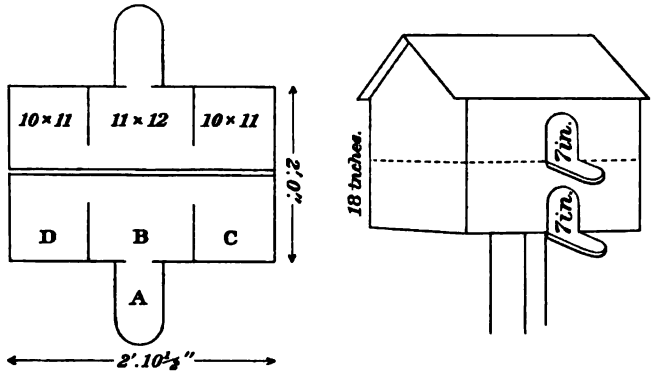


Fig. I.—Plan and elevation of a two-storied pole pigeon-house.

"A pair of birds take possession of the suits of apartments whose landing place is marked A. They will probably pass through the vestibule B, when they first bring in straws for a nest, and deposit them in one of the chambers, as C. When the young are a fortnight or three weeks old, the hen will probably leave them mostly to the care of the cock, and make a fresh nest and lay in the opposite apartment, D. As soon as the first pair of young are flown, C will be vacant for the hatching of a third brood, and so, by shifting alternately from parlor to study, and never being idle, a good pair of birds will produce quite a little flock by the end of the summer.

"It is easy to make use of this arrangement on a larger scale, or to apply it to the triangular frames of lockers which are fixed against barns and other outbuildings."

This plan is far superior to the ordinary pole-house, as offering much more accommodation to the sitting birds; the design, however, is capable of considerable improvement. If the sloping boards forming the roof were much larger, so as to extend farther over the ends and sides, the upper story would be more perfectly

sheltered from sun and rain; and if the alighting boards, or landing places (A A), extended along the entire length of the sides, they would be more convenient for the birds, and those belonging to the upper story would serve to shelter the lower nesting places from the weather.

Pigeon lockers, or houses placed against a wall, should have a southerly aspect, and be well protected by a broad, projecting, roof; but, under even the most favorable circumstances, they must be regarded as greatly inferior in productiveness to lofts or rooms.

It seldom occurs that a room is specially built for pigeons; but where there is any choice of locality it is best to select one that is open to the south, so as to get a warm aspect in winter and early spring, as that tends to encourage early breeding and is more healthy for the birds than a room exposed to the cold blasts from the north. It is not uncommon to see many pigeon-rooms on lofts that are very deficient in light; this is particularly objectionable. A dark room is not as healthy for the birds, especially if they are not suffered to fly out, and it can hardly be as well cleaned as one which is well lighted. Moreover, the owner is not able to see his birds conveniently, or to examine the nests when required.

VENTILATION.

Another point of the highest importance to the health of the birds, is the establishment of a good system of ventilation. Nine-tenths of the diseases that affect our high bred pigeons arises from their being crowded together in dark, dirty, ill-ventilated lofts. There is no necessity for an absolute draught of wind to be allowed to rush through the loft, but full provision must be made for ventilation if healthy birds are desired.

CLEANLINESS.

Cleanliness in the pigeon loft is no less essential than ventilation, particularly if many birds are kept, and they are not flown. The loft should be cleaned out daily. Under no circumstances should the dung be suffered to accumulate until it becomes offensive to the smell.

Fresh gravel, sand, or dry earth should be thickly strewn on the floor every day, and the dung that accumulates in the nest-boxes and around the nest-pans not suffered to collect so as to be offensive. The most convenient instrument for clearing the shelves will be found to be a small hoe fixed on a short handle about eight or ten inches in length.

Pigeons are often kept in lofts, or in the spaces under the tiles or slates of a house. In this case the rafters [bridging-joists] should be properly boarded over, otherwise the dung which falls upon the laths is with difficulty removed.

It is requisite that the room or loft devoted to pigeons should be proof against the ingress of cats, rats, or other vermin. Strange cats are most destructive to pigeons. When a cat has once tasted pigeon she seems to prefer it to all other food. Sometimes the access of a cat can hardly be prevented, and it may be necessary to get rid of the intruder to prevent the entire loss of the stock. A box-trap, baited with a pigeon's head, will be found to be invariably successful in the capture.

Rats are no less injurious than cats, and must be got rid of at all hazards. Traps, phosphorus paste, a trained cat that has been accustomed to pigeons from the first, may all be had recourse to.

The loft should, if practicable, admit of being divided, so as to enable the separation of the birds during the winter to be readily accomplished. With the more common hardy breeds this is not absolutely requisite, as in a well sheltered room they will go on breeding successfully nine or ten months out of the twelve; but with the more artificial and delicate high class varieties, it is useless to attempt to rear the young during the colder months of the year, and therefore it is desirable to separate the sexes after moulting time, or the autumn. This is most readily done by dividing

the loft. If the birds are flown, the division should be so arranged that the cocks and hens can be let out separately, and they may be given their liberty on alternate days.

THE AREA.

If the birds are flown, ingress and egress to and from the loft should take place through a cage, technically termed an area. (Fig. II.) This should be fixed outside

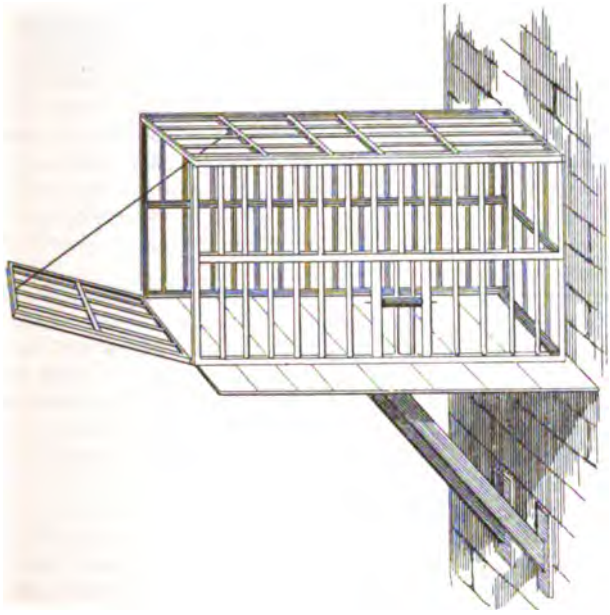


FIG. II.—Area for pigeon loft.

a window on a platform, which is usually supported by oblique struts. This area may either be constructed of laths or wires, and shonld have a falling door, to which is attached a string capable of being pulled from the inside, so as to close the entrance. It not unfrequently happens that some birds may be shut out when the door is pulled up; and in order to give these free access to the loft when the area is shut, two contrivances are used. One or more square holes, called dropping holes, are constructed in the top of the area, through which the pigeons can readily pass into the area, but out of which they cannot possibly emerge; the other is spoken of as the bolting wire. (Fig. III.) An apperture is left in the side of the area; at its upper part is fixed a small roller turning on a wire which passes through it, and into the stout laths that are on either side. From this roller hang two wires, placed nearly two inches apart, so as to give a pigeon space to put his head and neck through; these are quite unattached at the bottom, so that the bird pushing from the outside raises them and gains an easy entrance.

FIG. III.—Arrangement of bolting wires for area.

But the exit of birds from the interior is prevented by the wires resting against a small beading or piece of wood below, which hinders their being pushed outwards.

These two simple contrivances are of great service; they prevent birds being shut out at night, when they would often fall an easy prey to cats, give them at

any time free access to the loft, and save the owner from much anxiety and trouble. The birds learn to avail themselves of these means of ingress with the utmost readiness.

NESTS.

The furniture of the loft must now claim our attention. Not the least important, especially if many birds are kept together, are the breeding-places or nesting-boxes. These are of two kinds; in rooms that are rather crowded, shelves are generally placed around the walls, and the spaces between them are usually divided by upright divisions, placed not less than three feet apart, so as to form pens or breeding-places for the different pairs of birds. The distance between the shelves should not be less than eighteen inches, if Pouters are kept; but for the smaller varieties, a foot or fifteen inches will suffice. The ends of each pen should be boarded, so that the centre only is open. This arrangement offers several advantages; the bird in the nest, which may be formed at either end, sits concealed and undisturbed, a state of things that greatly conduces to success in hatching; and by hanging a piece of wire or lath-work before the open centre, the pen is capable of being closed, and the birds confined as long as may be desired.

The arrangement of having darkened nesting-places at both ends of the pen is very advantageous, as during the summer a pair of birds will often wish to go to nest before the last hatched young are able to fly and feed themselves. When this is the case, a second nest-pan may be put into the other end of the pen, when the birds will lay again, and thus rear a pair of young and sit at the same time.

When there is more room, and the birds are not so numerous, nest-boxes placed on the floor of the loft will be found more advantageous than shelves, for it prevents the young ones from falling out of their nests, which sometimes breaks a leg, and very often lames them, and also gives them a chance of being fed by other pigeons as well as their parents, which frequently happens. An old cock pigeon, who is a good father, will often take compassion upon a hungry squeaker which teazes him and runs after him begging for food, although it does not belong to him, and will cheerfully bestow upon it the contents of his crop. When nests are placed upon the floor breeding-boxes for the concealment of the nest are very desirable. They should be made without bottoms, so as to be merely covers to slip over the nests. One very convenient form is shown in Fig. IV. It consists of three sides of a cubical box, and half of a fourth, the bottom and side next the wall being absent. This is placed over the nesting-pan, and admits of being lifted off in an instant, either for the purpose of observation or for cleaning around the nest. One advantage of this form is that the cock bird usually takes his station over the nest of his mate, and thus does not interfere with the birds belonging to other nests, nor permit any intrusion on his own.

FIG. IV.—Square nesting-box.

Another form of nest-box is still more simple. It is formed, as shown in Fig. V, of an oblique and slanting board, resting against the wall; this is supported by a piece behind, not seen in the drawing, and a half piece in front; thus a convenient shelter for the nest is formed. It is always to be borne in mind that pigeons invariably prefer a concealed and snug retreat for incubation to any open place that may be afforded them, and, when they are allowed a chance, sometimes make strange selections.

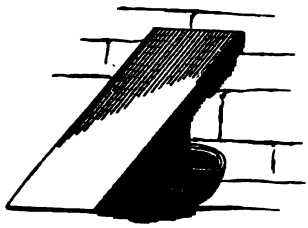


Fig. V.—Slanting nest-box.

Having tried every plan that has been suggested for the construction of nests, we know of none so advantageous as the employment of the coarse earthenware saucers known as nest-pans. These are formed usually of rough, red earthenware, and are best if made of the shape shown in Fig. VI; although for large birds, as Pouters and Carriers, some fanciers prefer the nest-pans to be rather flatter at the bottom than the one represented. In size these pans should vary with that of the different breeds; for small birds, as Tumblers, seven or eight inches in diameter is quite sufficient; but for Pouters, ten inches is not too great. These pans should be made heavy, so that they are not likely to be overset by the old birds resting on the edge. Some fanciers object to the use of nest-pans on account of the young occasionally falling out and perishing from cold. Others endeavor to obviate this evil by sinking the pan in a hole cut in the shelf or board on which it rests; but we have never found it necessary to have resource to this plan. The advantages of nest-pans over all other contrivances of the kind are very great. They are superior to boxes or baskets on account of the slight harbor they afford to vermin, and the ease with which they can be cleaned. Then the facility they afford for examining and shifting the young bird should not be lost sight of. They are much cleaner and more healthy in use than any other contrivance that can be employed. When the nestlings are very young, if the pan becomes wet, a handful of dry sawdust or bran speedily absorbs all moisture, and the nest becomes dry and wholesome, and, as the young become stronger, the dung is ejected over the sides of the pen, and the nest remains unsoiled. Some persons object to their employment, thinking that they are apt to chill the eggs; but we never experienced that evil, and the pans are readily made warmer by a little soft hay, cut straw, bran, or sawdust being placed within them.

Fig. VI.—Earthenware nest-pan.

We are convinced that with high-class, delicate, birds a very much larger number of young can be reared when nest-pans are employed than when they are not used.

When nests are made on the ground, some persons place a few bricks around them to prevent the eggs being rolled away; but the plan is far inferior to the employment of the nest-pan. In some parts of the country there may be some difficulty in getting these simple appliances; but, as they can be made by any brick, tile, or coarse earthenware maker, they should be accessible anywhere.

WASHING-PAN.

Another appliance, very necessary to the health and comfort of the birds, must not be overlooked,—that is, the washing-pan. Pigeons are not dusting birds, like fowls, but, on the contrary, cleanse themselves by washing; they are fond of lying down in shallow pools of water, expanding their wings, loosening the arrangement of the feathers, and then, when the plumage is well nigh saturated, they give a vigorous shake, and the water at once becomes quite white and milky with the scurf thrown off from the skin of the bird.

When kept in aviaries or in lofts, it is cruel to deprive them of this pleasure, so conducive to their well doing; and therefore shallow pans of water should be provided. In our own lofts we use milk pans for the purpose; but any broad, open vessels, capable of holding two or three inches' depth of water, will answer equally well.

CATCHING THE PIGEON.

As it is necessary to capture the bird at times, a common cheap landing net will be found a very useful article in the pigeon loft, as by its use a single bird can be readily caught, without driving the others about and frightening the sitting birds off their eggs and young.

DRINKING WATER.

A supply of drinking water is at all times an essential requisite. Pigeons are very thirsty birds, drinking a much greater amount of water than most persons would suppose possible; therefore a good supply is required. This is especially the case when the young are being fed, as, picking up a cropful of corn or pulse, the old bird has to take a copious draught of water before it can disgorge it into the throat of the young.

The old fanciers used to employ a large bottle filled with water, and then inverted into a saucer; but the contrivance is somewhat clumsy, and the common earthenware or metal poultry fountains will be found far more convenient in use. Many fanciers, who are particular about the food of their birds, care but little respecting the water given them. Too much stress cannot be laid on the fact that a supply of pure, clear drinking water is absolutely essential to the health of the birds. Often we have seen the owner of valuable pigeons bewailing his misfortune in losing so many by sickness, and when we looked at his drinking fountains we found that they contained water contaminated with filth, the presence of which quickly explained the diseased condition of his stock.

MATING CAGE.

Another very necessary appendage to the loft is a mating or matching-up cage. For the purpose of breeding birds of any desired properties, it is requisite that the parents should be matched together according to the judgment of the owner. For this purpose all that is necessary is to place them in a mating-cage for a few days.

It is merely an ordinary pen or cage, with an open wire partition separating the two birds; the cock is placed on one side, the hen he is desired to pair with on the other. It is desirable to remove this pen from the loft, and out of the sight of other birds, when the cock will be seen in a day or two making advances toward the hen; they may be then placed together, and as soon as the cock is seen calling the hen to nest, they may be regarded as paired, and returned to the loft. Sometimes, though rarely, it is necessary to keep them apart from the general flock a few days longer; but, generally speaking, there is but little trouble in matching birds together in any pairs that may be regarded as desirable.

One evil should be strongly guarded against in the lofts, namely, a superfluity of male birds, as odd cocks are constantly persecuting the hens that are mated, driving them off their eggs, and causing much fighting and turmoil. If there are too great a number of hens, the evil is much less, as a pair will often mate together, go to nest, lay and sit on four eggs, in the vain hope of rearing a brood; and, what is still more extraordinary, sometimes two cocks will match together in the same manner, and build a nest. If a pair of good eggs are given to them, they will even sit on the eggs, and hatch and rear the young, in the same manner as if they were a pair consisting of cock and hen.

FOOD.

With regard to the food of the birds, we are inclined to recommend a greater variety than that usually employed. The London fanciers are strongly in favor of

very small beans, regarding them as superior to all other articles, where the birds are large enough to take them; but the short-faced Tumblers cannot possibly feed their young even on the smallest beans, and therefore they are supplied with wheat and tares. Peas, both white and gray, are also extensively used. Whatever variety is employed, care should be taken to select old samples, as new peas, beans, or tares, are almost certain to purge the more delicate varieties. In America, Indian corn or maize is constantly used, being crushed for the use of the smaller breeds. In England, most fanciers have a great prejudice against its employment, but from long experience we can speak very favorably of it as a valuable addition to the dietary of the birds.

When pigeons are flown they become much more hardy than if confined to a loft, and only permitted to take exercise in a large area, or enclosed aviary. Under these circumstances, too much care cannot be exercised in the choice of their food; barley, tare-wheat, and even coarse rice, may form part of their food without danger. Pigeons flying in the country find a considerable portion of their own food, and even when an unlimited supply of pulse and grain is afforded them, they pluck off the small seeds of grasses, and eat a quantity of green vegetables, that greatly conduce to their well being. In the crops of the wild Rock Dove there is almost always found numerous small snails; and we have always noticed that such of our own pigeons that have their liberty, fly to the grass fields after a shower of rain, and pick up the smaller snails that are brought forth by the wet.

Believing that we cannot do better than follow the natural instincts of the birds in the matter of their food, we always strive to vary their dietary as much as possible, and give to those in confinement a green turf, or sometimes a cabbage or lettuce, to pick at.

It should be borne in mind that pigeons are derived from the Rock Dove, a bird frequenting the seashore and drinking the salt water of the pools left by the retiring tide. This may account for their *fondness for salt, a natural instinct* that it is most desirable to indulge. *They also require calcareous matter to furnish the materials of the egg-shell.* We endeavor to supply both of these desires at one and the same time, by mixing a little salt with a quantity of old mortar rubbish, and placing it where the birds can gain easy access to it.

If mortar rubbish is not accessible, we burn a few oyster shells, so as to render them brittle, then powder them up, with the addition of a little salt. Care must be taken not to supply salt or salt mixtures of this kind in too large quantity to birds that have long been deprived of this substance, as under these circumstances they are apt to eat so much that they injure themselves. The old fanciers used to make a nauseous and filthy compound they called "salt cat," for the delectation of their birds, but it offers no advantage over salt and mortar, or burnt shells, such as we have described. So fond are pigeons of salt that they will peck at any substance containing it. On one occasion the brine out of a barrel of Scotch herrings was emptied in our garden, and for many months the pigeons were to be noticed pecking at the mould around the spot, evidently attracted by the saline constituents of the brine. Many fanciers refuse to give their pigeons any salt, but it is difficult to believe that the gratification of so strong a natural instinct should not tend to the advantage of the birds.

CARRIER PIGEON.

The term Carrier, as applied to pigeons, evidently was first employed to signify those breeds that were used to convey or carry messages to their own homes from distant places. In the process of time it has been used by English fanciers to signify a very artificial or high class breed, the birds of which are never employed for carrying messages, but are valued solely in proportion to the perfection of certain "properties" that they possess. This is an unfortunate circumstance, for by the public at large the term Carrier is always taken to express the fact that the birds

to which it is applied are really those employed to "carry" messages; whereas the long distance flying birds, those known more correctly as "Homing" birds, or "Les Pigeons Voyagers," are totally distinct.

HOMING PIGEON.

We have now to consider the different kinds of Homing pigeons, or those that are remarkable for their powers of flight and their attachment to the home in which they have been reared and first flown. There are numerous varieties that exhibit this peculiarity, such as the Dragon, the ordinary flying Tumbler, and the Skimmer, or mongrel race between these two breeds. Among the pure breeds that can be flown good distances may be mentioned that called the Owl pigeon. But the varieties in which this homing faculty is developed to the highest degree are unquestionably the different races of Belgian birds, which are termed in England by the general name of Antwerps, and in Belgium are known as Smerles, Cumulets, Demi Becs, etc. Of these varieties the Smerles are the most important, as being the best known, and we therefore reproduce the following description from the pen of the editor, Mr. Tegetmeier, who writes:

"From the fact that many of the breed came from Antwerp, they are not unfrequently known as Antwerps.

"The Smerles are rather small birds, and look very much as if they had been originally bred from a rather coarse blue Owl pigeon, crossed with a Blue Rock. The head is arched, and the skull capacious, indicating a full development of brain, and offering a striking contrast to the flat, narrow skull of the English fancy Carrier. The most striking characteristic of these birds is the firmness and great breadth of the flight feathers of the wings. These overlap each other to a great extent, and afford a strong firm wing with which the flight is urged. The keel of the breast bone is deep and well covered with strong muscles; and there is altogether an absence of any offal or large development of any part not used in flight.

"In rapidity and power of flying these birds far exceed any other variety of pigeon with which I am acquainted. When I kept a large number I have often enjoyed watching the flight dart off in a gale of wind; and after being thus apparently swept away by the blast, witness them come back in the very teeth of the gale, with almost the same ease and rapidity as they would have done in a calm.

"This power of flight is conjoined with an attachment to home that is not surpassed by that of any other pigeon.

"In describing the Smerles, I have said nothing whatever respecting their color. The Belgian amateurs do not place the slightest value upon this property; they match up birds without any regard to color, and the result is that the Smerles can rarely be depended on for breeding tone to the color of the parents. Speed and endurance are the objects to be attained, and color is altogether disregarded. There is one color, however, that finds but little favor with the Belgian amateurs, and that is white. This dislike is not an unreasoning prejudice, but depends upon the fact that white birds are more conspicuous as they fly than those of darker color, and, consequently, are more apt to be destroyed by hawks and sportsmen.

"Setting whites, therefore, on one side, there is but little preference shown to any color; and mealys, blues, chequers, blacks, and blue or black pied are all looked upon with equal favor, if they possess the requisite power of wing to fly with equal rapidity.

"Smerles are the short-beaked pigeons of the province of Liege. They are remarkable for their intelligence, and also for the size of the skull and the well developed structure of the wings. When two years old they are capable of returning from Bordeaux to Liege or Verviers (a distance of over 500 miles) in twelve hours, provided the sky be clear and the wind favorable. In bad weather they return the following or the third day. The journeys from Tours (330 miles), Châttéllerant (365 miles), and Poitiers (380 miles), are performed by the same bird in eight hours.

"With regard to the value of these birds in Belgium, it is stated that a couple of young Smerles, warranted bred from birds that have been flown long distances, sell for 100 f.; and a pigeon which has carried off several prizes in the long distance matches will realize even as much as 500 f., equivalent to about £20 English.

"The training that these birds undergo is very severe. The young birds are taken to gradually increasing distances as their power of flight increases, so that eventually they are acquainted with all the conspicuous landmarks of long journeys. If it is attempted to train them too rapidly, or by too long stages, many of the birds are lost; whereas, by careful training, as practiced at Liege, only ten per cent. are lost in short courses, and only fifty per cent. even in very long distances. In this province they do not fly the young birds of the year more than seventy miles, nor ever attempt more than 200 miles the second year, leaving the longer and more severe distances for the older and more mature birds, that have acquired full development and experience.

"With regard to the faculty that these birds possess of returning home from long distances, I believe more erroneous statements have been written respecting it than on any other subject connected with pigeons. It is usually attributed to some mysterious power or instinct that these birds possess, and that is not possessed by Turbits, Fantails, Jacobins, or other varieties. I believe that instinct has nothing whatever to do with the homing power, but that the birds find their way solely by observation.

"Pigeons must be regularly trained by stages, or the best birds will be inevitably lost if thrown one hundred or two hundred miles.

"The best birds will refuse to fly in a fog; nor will I ever believe, except from personal experience, that a bird will fly home in the dark. I have tried many experiments, and lost many of my best birds in so doing. On one occasion I took a bird that had often flown fifty miles, to a distance of five miles, and threw him on a foggy day; he at once settled on the top of a house and remained there until the fog cleared off.

"A bird thrown in a new locality flies round and round in gradually increasing circles, until at length it discovers some familiar object, and then, and then only, darts off on its homeward flight. Throw the same bird again, in the same locality, and, if a good, intelligent bird, there is no wheeling round, but, the road being known, he is off instantly.

"I know I shall be met by the fact that no bird can see two hundred miles, to say nothing of five hundred. In that I perfectly agree; but no bird will return home two hundred miles, or oven one hundred, without he has been trained by stages on the road.

"And I may remark that as the earth's surface on a dead level curves eight inches in a mile, and that the curve increases as the square of the distance, it is very easy to calculate the range of vision from any altitude. Thus at a height of a little above four hundred feet, the extent of vision, even if the surface was a perfect level, as that of the sea, would be twenty-five miles on every side. But in every land view there are prominent objects that can be seen at much greater distances; and no one who has ever flown his pigeons but must have observed them looking on all sides, turning the head as they wheel round and round, until they discern some familiar object. In all questions that do not offer a ready solution there is a disposition to refer the effect to some mysterious agency beyond human ken. It is much easier to cut short the question of the homing faculty of pigeons, and call it instinct, than to investigate the facts of the phenomena."

To produce good birds, and continue the race, judicious crossing, continued to the right point, is requisite.

M. Coopers says that it is not desirable to hatch flying birds after the end of August, as the young pigeons do not make their full and regular moults, conseqently

cannot be trained the same year, and have not, during the following year, the value of young that are more timely bred.

It is well known that pigeons direct themselves by sight to the houses where they were reared. The Homing pigeons of Belgium, when liberated from the baskets in which they are forwarded great distances from home, fly round together; of those which take a wrong direction, a certain part return to the spot the next day, and are captured there, proving that they recognize even a new locality in an instant.

The Cumulets of M. A. Coopers are also known as Volants, or Highflyers; of these birds Mr. Kenrick, of Bruges, informs me: "The true-bred Volants are either black, white, or white with a little red on their necks and bodies. They have even whiter pearl eyes than Tumblers, and the black pupil of the eye is extremely small. They are most extraordinary birds to fly high, and have been known to keep on wing nine, ten, and eleven hours at a stretch. Their heads are not what is termed 'mousey,' but are more elegantly shaped than Tumblers. The best are clean-legged birds, but occasionally they are to be seen with feathered legs; but these are probably cross-bred. Two birds will fly together as well as a flock, which I do not think is generally the case with Tumblers."

TRAINING PIGEONS.

In training young pigeons to fill up the vacancies left by the loss or death of the old ones, it is desirable to allow them to make several trial flights. Though a pigeon at first sight may appear good, it may, nevertheless, have some defect which renders it unfitted for the purpose for which it is designed. By observation we can tell whether the wings of a young pigeon are well formed, but we cannot thus learn whether it has good sight, or whether its faculties are well developed; whereas the first trial to which the bird is subjected will satisfy us on these points.

A pigeon two or three months old, counting from the time when it leaves the nest, may be able to perform the journeys; but it is preferable to wait till it is five or six months old; and in practice, it is the pigeons hatched in March, April, and May which are subjected to those trials, which take place toward the end of August, or in September. A first flight of five to eight miles is flown; the second, three or four days after, will be double the length. In this manner, in five or six trials, a distance varying from 150 to 180 miles will be arrived at as the length of the flight.

These trials are amply sufficient, for the incapable pigeons will be lost on the road. The best will have shown their rapidity and excellence. A bird in training, which even in good condition has allowed itself to be constantly distanced, ought not to be kept, although it is possible that it may improve; as it happens sometimes that a pigeon for several years does not distinguish itself, and all at once gains several successes. A good deal is often said about these exceptions, but in general the best birds may be chosen after the early trials. A very good pigeon shows its superiority as well in its youth as at a more advanced age. In preserving very ordinary pigeons, the race is not being perfected.

A pigeon does not come to full strength till it is three years old. If in its youth it has been subjected to too severe exertions, it becomes easily exhausted, and at the age of four or five years, when it ought to possess its greatest vigor, it begins to decline, a journey of moderate length tires it, and if it does not remain on the road, it can scarcely follow even the last of those in the flight.

I much prefer the system of those amateurs who the first year submit their young pigeons to only short trials, allow them to form and develop during the second, and not until the third year permit them to make a journey of 300 to 400 miles. Thus they always possess good birds, which can with advantage take part in the contests where long distances are flown.

This consideration leads us to enquire into the conditions under which a pigeon is best fitted to take part in the contests.

As the great races take place in the second half of the month of July, it is desirable that the moulting of the birds should be retarded as much as possible. Indeed, at this time one frequently sees many pigeons which have only three or four of the largest winged feathers to lose.

This condition is to be lamented on two grounds: first, the absence of a large feather is more unfavorable than that of a small one, the long feathers increase in length from the minor to the outer ones, so that the second is more important than the third, and so on; in the second place, when the pigeon has arrived at the stage of its moult that there are only three or four feathers left, it is on the point of losing its scalpulary feathers and its wing coverts; the fall of these last constantly takes place in a rapid manner, and it may be so much accelerated by the short imprisonment of the birds in the baskets in which they are carried, that when they are set at liberty they may be found entirely deprived of an important instrument of flight. By chance a bird far in advance of its moult may succeed in gaining a victory, but such cases are exceptional, and will occur more rarely the more laborious the flight. A pigeon which has only commenced its moult, and has lost but three or four of its feathers, possesses a wing without gaps, and is in more favorable condition.

The majority of fanciers have more confidence in male than female birds; ordinarily, three-fourths of the birds employed in a flight are males—not that females are less faithful or less rapid than males, but because they are less often in good condition. For example, it is known that at the approach of the time of laying, and also during the two or three days which follow it, it is dangerous to employ a female. If she lays her two eggs in the basket in which she is carried, the state of weakness in which she arrives will cause her to fail. In the same way the female, being more employed in hatching than the male, perceives sooner the movements of the young pigeon in the egg; she feels that the time of coming out of the egg draws near, and prepares in consequence; the glands of the crop swell and secrete the milk which she gives to her little ones in the first day after their birth. If at this moment she is taken away from her maternal cares, to be shut up for several days in a basket, she will become ill, will cease to eat, and in all probability will be unable to regain her home. This last circumstance is also unfavorable in the case of the male bird, because he disgorges the same kind of milk for his little ones.

It is also necessary to watch that the pigeons should not exhaust themselves in rearing too many young; as a rule, only one young pigeon should be allowed to those parents that are about to take long flights.

Thus, during the two or three days which precede or follow laying, and also the hatching out of the young the female must not be employed; nor must the male during the three or four days which follow the hatching. It is often in the power of the amateur to defer the occurrence of these unfavorable circumstances. As the day of departure is known a long time beforehand, he may, by taking away the young, accelerate the period of a new laying, and also, a day or two before the hatching out, he may place a young pigeon of three or four days old in the nest, so that the parents may disgorge the soft food which fills their crops.

Besides the time indicated above, the question has been much agitated whether pigeons ought to be flown while they are sitting, or when they have young ones less than eight days old.

CATCHING THE PIGEON.

The operation of taking the pigeons in a closed pigeon-house appears very simple, and ordinary people would not imagine that it could be made an object of discussion. There is a plan employed which consists in catching the pigeons in their flight by means of a small net; the Belgian pigeon-houses are too small to allow of the use of this instrument, and even if they were larger it might not be generally adopted.

As a general rule more can be got from animals by affection than by cruelty, and pigeons are no exception to this. When an amateur takes care of his birds himself,

when he never frightens them by abrupt and hurried movements, the pigeons know him and will allow themselves to be taken with the greatest facility. We have even seen the master's dog go into the pigeon-house without even a single pigeon manifesting the least uneasiness. To catch the birds easily some have divided their pigeon-house by a movable partition; they bring their pigeons into the narrow space shut in by this partition, and in a few minutes their choice is made. Others shut out the light from the pigeon-house in such a manner as to produce darkness so great that the pigeons remain motionless. It is possible then to catch them without the risk of pulling out any feathers, or even of ruffling them.

Too many precautions cannot be employed during this operation, for a pigeon is rendered unfit for the contest simply by breaking one or two of the important flight feathers.

When the competitors are shut up in a basket it is well to pass them in review, and to make sure of the state of their wings. Attention should also be directed to the feet, in order to free them from any hardened dirt which may adhere to them. The feet, particularly those of large pigeons, often collect dung, which becomes hard in the pigeon-house. We can understand that this weight may overload a pigeon in its flight, and therefore attentive amateurs pass the finger, soaked in oil, over the lower surface of the bird's foot, so that excrements may not adhere to it.

BASKET FOR PIGEONS.

Great care has been taken in the construction of the boxes and baskets in which the pigeons are carried. The baskets are generally between four and five feet long, three feet wide, and about twelve inches high, and an opening about a foot long, shut by a movable door, is placed in the middle of one of the long sides. The bottom of the basket is covered with a thick coarse cloth; the baskets are made of stout willows stripped of the bark; these are placed at a distance of about one inch and a half from each other, so that they are wide enough apart for the pigeons to put their heads through and drink, but so close that no one can put in his hand to steal the birds. Before the birds are placed in the baskets the bottom is covered with a thin layer of perfectly dry tan; sometimes chopped straw or long straw is used instead, but the latter does not answer well, as the dung does not dry quickly, and the pigeons soon get very dirty. The chopped straw is too light, and it readily accumulates in one corner, leaving the remainder of the basket without litter; consequently the tan is much to be preferred, as it adheres to the cloth at the bottom and dries the damp dung.

In other provinces of Belgium baskets of another kind are used; they are not made of open work, but of closely woven willows, with square openings on one side, through which the pigeons can drink out of a vessel fastened to the outside. These latter baskets have the great advantage of being perfectly closed, and of lessening the liability to the loss of the birds from feline and other depredations. But they are heavy, and their carriage is more cumbrous and expensive.

At Liege the birds which are flown from a distance are always accompanied on the railway by a skillful person, who looks after them on the road and supplies them with food and water. In other places the boxes are addressed to the station-master or to the mayor of the town which has been selected as the commencement of the return flight; a label is fixed to the basket requesting the railway authorities to supply water to the birds and to give them some of the grain sent in a bag for that purpose.

These expenses are avoided by the second system, that followed in the provinces of Flanders and Brabant. The transport of pigeons is also made in a more rapid manner, for they are sent by express trains; while, in Liege, the ordinary trains are employed, in order to save expenses in the journey of the man who is sent with the pigeons. Another advantage is, that two or three amateurs can, if they wish it, join to have a supplementary flight of their birds; whereas, if they employ a man the

matter would be more difficult to organize, and the expenses would be too much increased.

Thus by the one system we can have cheapness and rapidity, and by the other we secure care being taken of the pigeons, both during their journey and at the time of letting them fly. After making a trial of both plans, and weighing the advantages and drawbacks of each, the balance, at least in Belgium, seems to be in favor of the plan of employing a man to take charge of the birds. When the pigeons are addressed to the care of the station-master, it is a rare thing for them to be flown at the time desired; a delay of several hours makes the amateur who expects them impatient—the pleasure which he promised himself becomes a source of annoyance to him. The baskets with the birds may remain neglected in the station; if rain comes on the pigeons become wet; the dung which covers the bottom of the baskets dirties their plumage, and may clog their wings to so great an extent that half of the birds may find it impossible to perform their flight.

HABITS OF THE PIGEON ON A VOYAGE.

When the ground is covered with snow, pigeons seem to miss their point of guidance and are lost. This would seem to favor the opinion that they travel by sight, and are less indebted to instinct than is generally imagined. Homing pigeons do not fly at night; they settle down if they cannot reach their home by the dusk of evening, and renew their flight at daylight next morning.

The birds taking part in these contests are entered soon after they are able to fly—the quill or flight feathers of the wing being stamped with the distinguishing mark of the particular race, and a fixed sum contributed weekly by the owners towards the prize which is to be competed for.

As soon as the young birds can fly strongly their training commences. They are taken, day after day, to gradually increasing distances from home, and then liberated. In this manner both their observation and power of flight are exercised, until at last they know their way accurately, and can fly back long journeys without loss of time.

A pigeon could not fly encumbered with a letter; and when a bird is employed for conveying a message a narrow slip of paper is written on, rolled round its leg, and secured by a thread. As the leg and foot, during flight, are drawn up into the soft feathers, the paper so attached offers no impediment to the speed of the bird.

THE DISEASES OF PIGEONS.

In consequence of the artificial conditions under which domesticated pigeons are reared and nurtured, they are liable to a variety of diseases which appear to be unknown to the birds in their natural state.

The causes of nearly all the diseases affecting pigeons are the unnatural conditions under which they are maintained. If the birds are kept in localities where they can be permitted to fly at large, houses in well sheltered lofts that are frequently cleaned, and are supplied with a sufficient amount of wholesome food and a constant supply of clean water, disease will be almost, if not entirely, unknown amongst them. But if overcrowded and confined in dirty lofts, the atmosphere is charged with the exhalations from the dung of the birds, more especially if fed from the floor, where the food becomes contaminated with the dung, and supplied with water that is fouled by the same cause, the birds become unhealthy and subject to scrofulous and other diseases that are unknown when they are maintained in more natural and healthy conditions.

The most frequent of these diseases are known to English fanciers under the name of roup, canker, wing disease, staggers, purging, and fallen gizzard.

It will, however, be more advantageous to consider these diseases in a somewhat more methodical manner, as several are really but different manifestations of the same disease.

Scrofula in pigeons, as in the human subject, makes itself manifest in several apparently distinct diseases. It is produced in birds by similar causes to those that develop it in man, namely, bad food, foul water, overcrowded, unhealthy dwelling places, and deficiency of fresh air and exercise.

Wing disease is one of the most common forms in which scrofula occurs; it consists essentially in a deposit of cheesy scrofulous matter in and around the joints, the elbow joint being the one most frequently affected, apparently from the circumstance of its being largely extended in flight. In the early stages, wing disease may be cured by the application of tincture of iodine, which causes the absorption of scrofulous deposit, attention being paid to the general health of the bird; but, in advanced cases, recovery is hopeless. In many cases of partial recovery from the disease a stiff joint remains, and the bird is incapable of flight. A cock bird with such a deposit is perfectly useless, but a hen may still be bred from; although, unless her characteristics are of unusual excellence, we should strongly advise her destruction, scrofula in all its forms being one of the most hereditary of diseases.

Roup is a disease affecting the mucous membranes lining the mouth, nostrils, and air passages, and often extending up the tear ducts into the eyes. It is a low form of inflammatory action, resembling a severe cold or influenza. In bad cases it becomes purulent, matter is formed in the eyes and nose, an offensive discharge takes place, and in this condition there can be no doubt that the disease is contagious; the affected bird in drinking contaminates the water, and so affects those who drink after it. Roup may originate at any time by exposure to cold and wet, either in the loft or at an exhibition or railway station; consequently, valuable and delicate birds should always be sent to shows in hampers, the sides of which are lined with canvas.

Warmth alone will not infrequently restore those birds that are but slightly affected. In more advanced cases we have found capaiba balsam, which has an almost specific effect on mucous membranes, very advantageous. The most ready way of administering it is to procure some of the gelatinous capsules containing the drug, and give one at night to the affected bird. In severer cases, where the discharge is offensive and purulent, a few drops of lotion made of five grains of nitrate of silver (lunar caustic), in an ounce of rain or distilled water, may be applied to the eye; but it should be remembered that this stains the skin of the fingers or any animal substance with which it comes in contact. During roup the birds should be kept very warm and well nourished with stimulating food, such as hemp seed.

Sore eyes (conjunctivities) is particularly common in Carriers and Barbs, owing to the great development of wattle around the eye and the tendency that old birds have to the formation of spouts by the turning out of the lower lid. The lotion of lunar caustic is very effectual in these cases, or, if preferred, a very small fragment of an ointment composed of five or even ten grains of lunar caustic to an ounce of unsalted lard may be employed. The spouts, as they are termed, may be removed by being cut from below upwards with a pair of very sharp scissors.

Canker is a peculiar growth that takes place from the mucous membrane lining the mouth and throat. Sometimes it forms in large masses, that require to be dissected away carefully. It is a troublesome disease to cure; but the application of powdered burnt alum, or a solid point of lunar caustic, after the removal of the white diseased growth, is often effectual in removing the complaint.

Vermin.—Pigeons are infested with numerous parasites. Four distinct species of lice are found upon them, the most common, and by far the most remarkable, being the *Lipeurus baculus*, the feather louse of fanciers. This, in the living bird, is generally found between the vanes or fibres of the feathers, for which habitation its peculiarly elongated form particularly adapts it. Its body is dull yellow, its head and chest being bright chestnut. The male and the female may be distinguished by the form of their feelers, those of the male only being hooked. After death the feather louse collects on the feathers on the head and neck, where it is sometimes

found in large numbers. Pigeon fanciers do not regard it as injurious, but it must derive its sustenance from the body of the bird. There is also a small mite, a species of *Acarus*, that during summer, in overcrowded dirty lofts, appears to annoy the birds to a very great extent, infesting the cracks in the nests, walls, and perches in countless thousands. A large tick, a species of *Ixodes*, as large as a tare when full grown, is sometimes found on the birds. Its size is so great that it may be observed through the feathers; and, lastly, a peculiar flea, the *Palex columbæ*, is often found in dirty lofts.

Cleanliness is the great preventative of these pests. The lice and mites may be destroyed by dusting sulphur under the feathers, or the Persian insect powders may be used in the same manner. A little Paraffine oil, or, still better, the more volatile spirits known as vegetable or mineral turpentine, poured on the perches, soon expels them; and, in very bad cases, a single drop may be placed in the feathers of the bird.

Scouring or *diarrhœa*, is not uncommon in delicate birds not flown, or in those fed on bad food. When arising from the latter cause the remedy is obvious. In delicate birds it may often be checked by a little astringent, such as a grain of green vitriol or sulphate of iron; or, if all the birds are affected, a sufficient amount of sulphate of iron may be added to the drinking water, to give it a decidedly inky taste.

Vertigo.—Highly fed pigeons are subject to some diseases of the nervous system, manifesting themselves in vertigo or giddiness, staggers, and unnatural twisting of the head. Constrained abstinence from food for two or three days, and very moderate feeding subsequently, are the most likely remedies to prove effectual.

APPENDIX.

The home of the pigeon should be as conspicuous as possible. Notwithstanding the fact that the flag at posts will generally make the home of the birds in the military service noticeable at a long distance, it is suggested that when it is possible the flag-staff be surmounted by a large spherical reflector, or a large white ball.

That their arrival from a voyage may be quickly known, they should announce themselves. This can be arranged by connecting, by means of a light wire, the door of their house or loft through which they enter with a bell in a room that is habitually occupied. The wire need only be attached when messengers are expected. It therefore appears the Medical Department at posts should have charge of the pigeons in the military service, and that their loft be near the hospital. Not only will they then be most likely to receive constant care, but judicious attention; and in return may be expected to interest and be a direct benefit to the patients in hospital.

The best means of catching the bird when he enters the loft is with a butterfly net.

Although it is important to send the same message by several birds, they should not be sent off together, but tossed up at intervals of five or ten minutes. When thrown off together, especially if in good condition, they sometimes play and loiter.

○

UNITED STATES (OF AMERICA:) — Signal service.
WAR DEPARTMENT.

Prof. 8

SIGNAL SERVICE NOTES

No. III.

TO FORETELL FROST.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY.

BY

JAMES ALLEN,
1ST LIEUTENANT, 3D CAVALRY, A. S. O. AND ASST.

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C.
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1882.

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NOTE.

The foretelling of FROST is of such great and evident importance, that the following Signal Service Note, by 1st Lieutenant James Allen, Acting Signal Officer and Assistant, is in every way worthy of close attention and of the widest circulation.

WASHINGTON CITY, *September* 15, 1882.

TO THE CHIEF SIGNAL OFFICER, U. S. A.,

Washington, D. C.

SIR: The accompanying notes will be of great value to horticulturists, and others, who live at places not reached by the bulletins of this service giving warnings against frosts. I therefore suggest their publication.

Very respectfully, your obedient servant,

JAMES ALLEN,

Acting Signal Officer and Assistant.

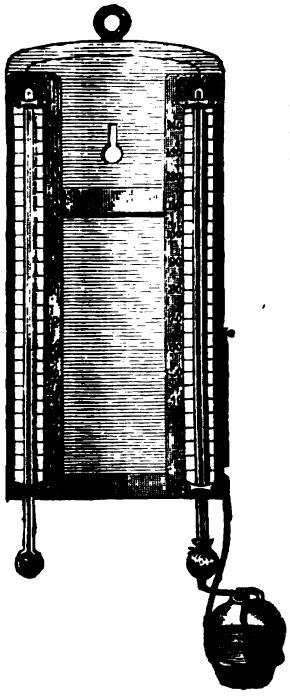
TO FORETELL FROST BY DETERMINATION OF THE DEW-POINT.

THE HYGROMETRY OF THE ATMOSPHERE.

At all temperatures, even the lowest, moisture exists in the atmosphere in an invisible state ; the air is never absolutely dry. The intervals between the particles of air are partly filled with the vapor that is constantly rising from the earth. This capacity of the air for moisture has a limit, and when this is reached the air is said to be saturated. This vapor is not sustained in the air like water in a sponge, nor does it float in the air like small particles of dust, but it penetrates between the particles of the permanent gases which compose the atmosphere, and sustains itself precisely as they do. A rise of temperature increases the capacity of the air for moisture. On the other hand a fall of temperature diminishes the capacity. But the capacity of the air for moisture increases more rapidly than the temperature.

Thus, air can contain at 32° the 160th part of its own weight, at 59° the 80th part, and at 86° the 40th part, the law being that for every increase of 27° the capacity is doubled.

The amount of vapor in the air may be measured with great accuracy by noting the temperature at which moisture begins to be condensed on a cold vessel. The moisture thus deposited is called dew, and the temperature at which this deposition begins is called the dew-point. The dew-point, then, may always be determined by cooling a metalic vessel until dew begins to appear upon its surface and noting, by a thermometer, the temperature of the vessel. Thus, a thermometer is placed in a polished metal cup and small pieces of ice are dropped in until moisture appears on the surface of the cup. At the instant this occurs the thermometer is read. The temperature indicated is the dew-point. In this experiment, however, the results are approximate, and, as it requires considerable time, various contrivances have been proposed to facilitate it, but one of the best methods is that of the dry and wet-bulb hygrometer, and is here described.



THE DRY AND WET-BULB HYGROMETER.

This hygrometer consists of two mercurial thermometers, which, being placed side by side, would indicate the same temperature. The dry-bulb is a common thermometer, intended to show the temperature of the air. The wet-bulb is also a common thermometer, but having its bulb covered with a piece of thin muslin, from which passes a few threads of darning-cotton or narrow strip of muslin into a small vessel containing rain-water. Water rises by capillary attraction from the vessel and thus keeps the muslin constantly wet. When the air is dry, evaporation from the muslin proceeds rapidly, and, on account of the heat lost in this way, the wet-bulb indicates a lower temperature than the dry-bulb; when the air is damp evaporation is slower, and the difference between the two thermometers becomes less, and where the air is completely saturated evaporation ceases, and the two thermometers indicate the same temperature.

To keep this instrument in working order, one or two things require special attention. The thermometers must be alike, for if one is filled with mercury and the other with spirit, or if they contain different quantities of the same fluid, the readings will be vitiated.

All starch or foreign matter should be washed out of the thin muslin covering and the cotton wicking. The water used should be pure; for if lime or other salts be dissolved in it, the muslin will soon be coated with a calcareous or other incrustation. Rain or distilled water should be used. The muslin ought to be changed when covered with dust or other impurities, and care should be taken not to touch the muslin with the fingers, otherwise it will get slightly greased, and capillary attraction will be there by interfered with. The bulbs of the thermometers should be made to project one and one-half or two inches below the scales. The thermometers should also be a little apart from each other, and the vessel containing the water be, as in the figure, as far removed as possible from the dry-bulb. The thermometers should be exposed to the air where the circulation is unobstructed. They should face the north and should be always in the shade. They should be removed at least a foot from the wall of any building, and should be about ten feet from the ground. They should be protected against the heat reflected by neighboring objects, such as buildings or a sandy soil, and they should be sheltered from the rain. If the dry-bulb should become moistened by rain, the bulb should be carefully dried about five minutes before making the observation; since drops of water, by their evaporation would lower the temperature of the mercury in the bulb.

The dew-point can be readily determined by the following rule and table:

Rule: Subtract the reading of the wet-bulb from that of the dry-bulb; find the temperature of the dry-bulb in the left-hand column of the table, opposite which, in the column that is marked at the top with the difference between the dry and wet-bulb, is to be found the dew-point sought.

Example: Dry-bulb, 47°
Wet-bulb, 40°

Difference of depression of wet-bulb, 7°

Looking for the temperature of 47 on the left of the table we find opposite in the column under 7° the figure 28, which is the dew-point.

DEW-POINT.

Air temp.	Difference between reading of Wet and Dry-Bulb.														Air temp.
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
+30°	+30°	+27°	+24°	+21°	+17°	+13°	+ 7°	− 1°	−11°	−30°					+30°
31	31	28	25	22	18	14	9	+ 2	− 7	−23					31
32	32	29	26	23	20	16	11	5	− 3	−17					32
33	33	30	27	24	21	17	13	7	− 1	−12	−32				33
34	34	31	28	25	22	19	15	9	+ 2	− 7	−23				34
+35	+35	+32	+29	+26	+24	+20	+16	+11	+ 5	− 3	−17				+35
36	36	33	30	27	24	21	18	13	8	− 1	−12	−32			36
37	37	34	32	29	25	21	19	15	9	+ 3	− 7	−23			37
38	38	35	33	30	26	23	19	17	11	6	− 3	−16			38
39	39	36	34	31	28	24	20	16	14	8	0	−11	−31		39
+40	+40	+37	+35	+32	+29	+26	+22	+18	+12	+10	+ 3	− 6	−22		+40
41	41	39	36	33	30	27	23	19	14	8	6	− 2	−15		41
42	42	40	37	34	31	28	25	21	10	10	3	+ 2	− 9	−29	42
43	43	41	38	35	33	30	26	22	18	13	6	− 3	− 5	−20	43
44	44	42	39	37	34	31	27	24	20	15	9	+ 1	−12	−28	44
+45	+45	+43	+40	+38	+35	+32	+29	+25	+21	+17	+11	+ 4	− 7	−27	+45
46	46	44	41	39	36	33	30	27	23	19	14	7	− 2	−18	40
47	47	45	43	40	37	35	32	28	25	21	16	10	+ 2	−11	47
48	48	46	44	41	39	36	33	30	20	22	18	12	5	− 6	48
49	49	47	45	42	40	37	34	31	28	24	20	15	8	− 1	49
+50	+50	+48	+46	+43	+41	+38	+36	+33	+29	+26	+22	+17	+11	+ 3	+50
51	51	49	47	45	42	40	37	34	31	27	23	19	13	6	51
52	52	50	48	46	43	41	38	35	32	29	25	21	16	9	52
53	53	51	49	47	44	42	40	37	34	30	27	23	18	12	53
54	54	52	50	48	46	43	41	38	35	32	28	24	20	15	54
+55	+55	+53	+51	+49	+47	+45	+42	+39	+36	+33	+30	+26	+22	+17	+55
56	56	54	52	50	48	46	43	41	38	35	32	28	24	19	56
57	57	55	53	51	49	47	45	42	39	36	33	30	26	22	57
58	58	56	54	52	50	48	46	43	41	38	35	31	28	24	58
59	59	57	55	53	51	49	47	45	42	39	36	33	29	26	59
+60	+60	+58	+56	+54	+52	+50	+48	+46	+43	+41	+38	+35	+31	+28	+60
61	61	59	57	56	54	52	49	47	45	42	39	36	33	29	61
62	62	60	58	57	55	53	51	48	46	43	41	38	35	31	62
63	63	61	60	58	56	54	52	50	47	45	42	39	36	33	63
64	64	62	61	59	57	55	53	51	49	46	44	41	38	35	64
+65	+65	+63	+62	+60	+58	+56	+54	+52	+50	+48	+45	+42	+39	+36	+65
66	66	64	63	61	59	57	55	53	51	49	46	44	41	38	66
67	67	65	64	62	60	58	56	54	52	50	48	45	43	40	67
68	68	66	65	63	61	59	58	56	54	51	49	47	44	41	68
69	69	67	66	64	62	61	59	57	55	53	50	48	45	43	69
+70	+70	+68	+67	+65	+63	+62	+60	+58	+56	+54	+52	+49	+47	+44	+70
71	71	69	68	66	65	63	61	59	57	55	53	51	48	46	71
72	72	71	69	67	66	64	62	60	58	56	54	52	50	47	72
73	73	72	70	68	67	65	63	61	60	58	56	53	51	49	73
74	74	73	71	69	68	66	64	63	61	59	57	55	52	50	74
+75	+75	+74	+72	+70	+69	+67	+65	+64	+62	+60	+58	+56	+54	+51	+75
76	76	75	73	71	70	68	67	65	63	61	59	57	55	53	76
77	77	76	74	72	71	69	68	66	64	62	60	58	56	54	77
78	78	77	75	74	72	70	69	67	65	64	62	60	58	55	78
79	79	78	76	75	73	71	70	68	66	65	63	61	59	57	79
+80	+80	+79	+77	+75	+74	+73	+71	+69	+68	+66	+64	+62	+60	+58	+80
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	

The ascertainment of the dew-point is of great practical importance, particularly to horticulturists, since it shows the point near which the descent of the temperature of the air during the night will be arrested. For when the air has been cooled down by radiation to this point, dew is deposited and latent heat is given out. The amount of heat thus set free being great, the temperature of the surrounding air is immediately raised. The same process continues to be repeated, and thus the temperature of the air in contact with plants and other radiating surfaces may be considered as gently oscillating about the dew-point. For if it rises higher, the loss of

heat by radiation speedily lowers it. Thus the dew-point determines the minimum temperature of the surface of leaves on the ground during the night. The minimum temperature in the instrument-shelter would be higher than this.

This suggests an important practical use of the hygrometer. If the dew-point be ascertained by it, the approach of low temperatures or of frost may be foreseen and provided against. Thus, suppose on a fine clear day, towards evening, that the dry-bulb is 50° and the wet-bulb 40°, the dew-point at the time is therefore 22° F. Frost on the ground may then be predicted with certainty, and no time ought to be lost in protecting such tender plants as may be exposed in the open air. If, on the other hand, with a sky quite as clear, the dry bulb is 50° and the wet bulb 47°, the dew-point being thus 43° no frost need be feared.

This table shows the temperature and dew-point at 3 and 11 p. m., and the minimum temperature during the night—all the instruments exposed in an instrument-shelter.

Station.	Date.	Minimum temperature at 7 a. m.	3 P. M.		11 P. M.	
			Previous day.			
			Ex. ther.	Dew point.	Ex. ther.	Dew point.
	1881.	°	°	°	°	°
Fort Verde, Ariz.	October 15...	31.9	72.6	21	56	36
Camp Thomas, Ariz.	" 17...	31.5	69	25	56.5	22
Do	" 18...	32	68 5	28	48.5	26
Ploche, Nev	" 25...	32	51	31	38	31
Do	" 29...	32	48	26	36	26
Do	" 30...	32	47	21	39	23
Prescott, Ariz.	" 19...	32	69	21	44	20
Do	" 25...	32	61	40	44	35
Do	" 29...	32	54	35	47	43
Do	" 31...	32	64	26	45	25
Silver City, N. Mex	" 17...	32	68	44	42	24
Do	" 28...	32	46	35	40	36
Do	" 31..	32	62	39	40	30
Atlanta, Ga.	November 20...	32	63	58	40.5	32
Campo, Cal	" 19...	32.2	48.6	13	44	6
Coleman City, Texas	" 26...	32	59	32	42	32
Dodge City, Kans.	" 10...	32	47.6	26	39	25
Denison, Texas.	" 23...	32.5	41.5	35	36.2	33
Concho, Texas	" 19...	32	49	35	42	29
El Paso, Texas.	" 4...	32.3	57.1	16	41.2	28
Do	" 30...	32.5	60.5	22	52	24
Florence, Ariz.	" 2...	32.5	66.6	30	15.6	30
Do	" 27...	32.5	70.4	23	44.1	24
Fort Gibson, Ind. T.	" 3...	32	46.5	34	41.2	36.2
Fort Grant, Ariz.	" 2...	32	56	13	40	16
Do	" 3...	32	54	7	40	18
Do	" 10...	32	45	34	40	36
Do	" 24...	32	57	3:	50	19
Do	" 26...	32	57	28	44	20
Fort Sill, Ind. T.	" 9...	32.5	51.2	32	40.8	35
Fort Verde, Ariz.	" 6...	31.9	64.5	22	48.4	21
Do	" 14...	31.9	65.1	38	48.4	31
Do	" 15...	32	60.9	38	50.2	34
Hatteras, N. C.	" 25...	32	47	37	39	28
Jacksborough, Texas.	" 22...	32	48	39	43	35
Do	" 23...	32	48	39	42	34
Jacksonville, Fla.	" 25...	32	58	35	42	21
Knoxville, Tenn.	" 16...	32.3	54.2	20.4	43	30
Do	" 21...	32	44.5	17.5	35.3	26.9
La Mesilla, N. Mex	" 4...	31.5	62.3	22	40	27
Mobile, Ala	" 27...	32	55	30	42	31
New Orleans, La.	" 25...	31.5	45.5	21	38.5	18
Ploche, Nev.	" 27...	32	56	13	43	9
Prescott, Ariz.	" 7...	32	63	20	51	16
Santa Fé, N. Mex.	" 4...	32	42.3	26	37	30
Do	" 6...	31.8	53	36	36	24
Stockton, Texas.	" 22...	32	55.3	32	40	30
Tucson, Ariz.	" 29..	32	73	25	52	24

Assuming the sky to remain perfectly clear of haze or clouds, the raising or depressing of the dew-point during the night, (usually with a change of wind,) are the only circumstances that can happen to interfere with the predictions founded on the hygrometer. Frequently the presence of haze at high altitudes during the night

prevents the radiation of heat from the earth and thereby the frost which otherwise would have occurred.

Hoar-frost is formed under the same circumstances as dew, with the exception of a lower temperature. When the temperature of the surface of plants falls below 32° the moisture of the air is condensed upon them in the solid state and forms a layer of snow-crystals, like spongy ice. Hoar-frost therefore is not frozen dew, but the moisture of the air is deposited in the solid form, without having passed through the liquid condition. Hoar-frost, like dew, is deposited chiefly upon those bodies which radiate best, such as plants and the leaves of vegetables, and the deposit is made principally on those parts which are turned toward the sky.

Since plants sometimes become cooled by radiation from 12° to 15° below the temperature of the surrounding air, a frost may occur although a thermometer a few feet above the ground, in an instrument-shelter, may not sink to 32°. During a clear and still night, when a thermometer six feet above the ground sinks to 36°, a heavy frost may be expected; a slight frost may occur when the same thermometer sinks only to 47°.

Whatever prevents the radiation of heat serves also to check the formation of hoar-frost. During the cold nights of spring, plants which are sheltered by trees are less liable to be injured by frost than those which are fully exposed, and a thin covering of cloth or straw will generally afford entire protection. A garden may frequently be saved from injury by kindling a small smudge fire, which will envelop the plants in a cloud of smoke. Fogs and clouds also protect vegetation from the effects of frost.

All instruments should be of known reliability, and should therefore be of standard make, and their accuracy determined by comparison with standards before being used.

Accurate instruments will be procured for observers at actual cost price; they will be compared with standards at this office, and correction cards furnished free of charge.

A complete hygrometer costs $7.00.

A minimum thermometer is a very useful auxillary to the above instrument. It costs $5.00.

The alcohol minimum thermometer consists of a glass tube, the bulb, and part of the bore of which, is filled with perfectly pure spirits of wine, in which moves freely a colored glass index. A slight elevation of the thermometer, bulb uppermost, will cause the glass index to move to the surface (top of the column) of the liquid, where it will remain, unless violently shaken. On a decrease of temperature, the alcohol recedes, taking with it the glass index; on an increase of temperature, the alcohol alone ascends in the tube, leaving the end of the index farthest from the bulb, indicating the minimum temperature.

Directions for using, &c.—Having placed the glass index at the end of the column of spirit, by slightly tilting the thermometer, bulb uppermost, suspend the instrument in the shade, with the air passing freely to it on all sides, by the two brass plates attached for that purpose, in such manner that the bulb is about half an inch lower than the upper end of the thermometer; then, on a decrease of temperature, the spirits of wine will descend, carrying with it the glass index; on an increase of temperature, however, the spirits of wine will ascend in the tube, leaving that end of the small glass index farthest from the bulb, indicating the minimum temperature. To reset the instrument, simply raise the bulb end of the thermometer a little, as before observed, and the index will again descend to the end of the column, ready for future observations.

Precautions.—1. By no means jerk or shake an alcohol minimum thermometer when setting it, for, by so doing, it is liable to disarrange the instrument, either by

causing the index to leave the spirit, or by separating a portion of the spirit from the main column.

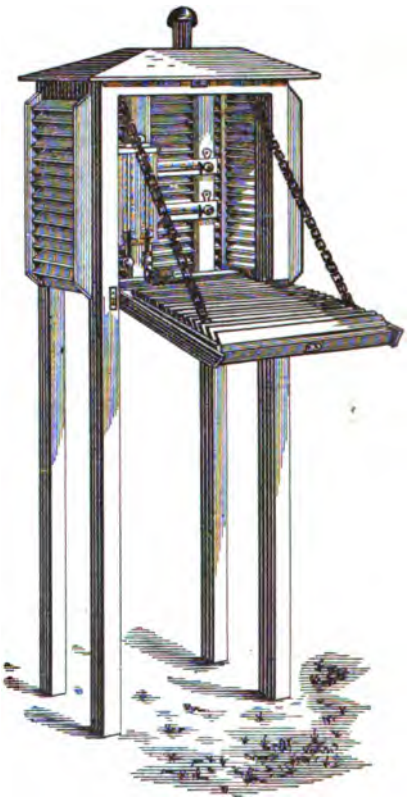
2. As alcohol thermometers have a tendency to read lower by age, owing to the volatile nature of the fluid allowing particles in the form of vapor to rise and lodge in the tube, it becomes necessary to compare them occasionally with a mercurial thermometer whose index error is known, and if the difference be more than a few tenths of a degree, examine well the upper part of the tube to see if any alcohol is hanging in the bore thereof; if so, the detached portion of it can be joined to the main column by swinging the thermometer with a pendulous motion, bulb downward.

3. The spirit column is sometime much broken by jolting in travelling. If the instrument is in such a condition when received, it should be held by the right-hand, bulb downward, and the frame tapped smartly, but cautiously, against the palm of the left-hand. The broken thread of spirit will soon begin to join, and, by continuing the operation a sufficient time, all the bubbles will disappear, and the thermometer become as good as ever.

The top of the thermometer will be fastened by the small brass screw upon the support, while the lower end will be dropped into the notch to the left.

The instrument is read by observing the number of degrees upon the scale where the top of the index rests.

Whenever it is practicable, an instrument-shelter should be built.



The Stevenson pattern shown in the figure is a very good one. The louvres are double, sloping in opposite directions, so that while there is access of the air to the inside, the radiant heat and rain are effectually excluded. A single lattice, however, will answer the purpose very well.

This screen should be erected on legs four feet high, and should stand over grass on open ground. It should not be under the shadow of trees nor within twenty feet of any wall.

Precautions in reading thermometers.—To read a thermometer accurately requires some little care.

1st. The eye must be exactly at the level of the reading, if the thermometer is vertical; and in all cases must be so situated that a line drawn from the eye to the top of the column would be perpendicular to the column. If the graduation is not on the tubes, and the eye is above the top of the column, however little, the reading will be too low, and *vice versa*. This is a point frequently neglected by careless observers.

2d. The thermometer must be read quickly, and the face and head must not be very near it; otherwise it will be affected by the warmth radiated from the body.

THE SIGNAL SERVICE SYSTEM OF FROST WARNINGS.

The system of warnings to be sent from this office, as arranged for up to this date, is as follows:

The forecasts will be made as early as may be with reasonable safety. They will be furnished to the press in the special bulletins issued daily from this office at 1.00 a. m. and 10.00 a. m.

For the benefit of the sugar interests, they will be sent by special message to New Orleans, whence they will be furnished to the press and to the Sugar Planters' Association. They will also be distributed from New Orleans, by telegraph, to the plantations.

They will also be sent by special message to Galveston for the press and the Cotton Exchange, and for distribution, by telegraph, to the plantations.

A special message will also be sent to Alexandria and Natchitoches, Louisiana.

For the tobacco interests, forecasts will be sent by special message to Madison, Wis.; from thence the warning will be repeated to 20 stations: Saint Louis, Mo., 83; Cincinnati, Ohio, 49; Springfield, Mass., 5; Hartford, Conn., 22; New Haven, Conn., 46; Elmira, N. Y., 17; Lancaster, Pa., 9; Wilmington, N. C., 11; Harrisburg, Pa., 82; York, Pa., 8; Washington, D. C., 21; Richmond, Va., 8; Lynchburg, Va., 31; Raleigh, N. C.,19; Memphis, Tenn., 22; Nashville, Tenn., 27; Lexington, Ky., 17; Louisville, Ky., 65; Hannibal, Mo., 20, and Palmer, Mass., 7.

For the fruit-growers in Florida, warnings will be sent by special message to Jacksonville.

For the cranberry-growers, warnings will be sent by special message to selected points in Camden connty, New Jersey, and Barnstable county, Massachusetts.

O

Prof. S

UNITED STATES OF AMERICA:
WAR DEPARTMENT.

SIGNAL SERVICE NOTES

No. IV.

THE USE OF THE SPECTROSCOPE

IN

METEOROLOGICAL OBSERVATIONS.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY.

BY

WINSLOW UPTON, A. M.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF WAR

WASHINGTON:
OFFICE OF THE CHIEF SIGNAL OFFICER.
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UNITED STATES (OF AMERICA:) — Sig. . . l service.
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1884, No. 12.

U. S. Naval Observatory.

USE OF THE SPECTROSCOPE IN METEOROLOGICAL OBSERVATIONS.

About ten years ago it was suggested by Professor Piazzi Smyth, Astronomer Royal of Scotland, that the variable lines in the solar spectrum, due to the absorption of aqueous vapor, might be made available for the forecasting of rain. This conclusion he justified by numerous experiments, which he has continued to the present time, and which have been repeated by other observers with similar results.

The object of this paper is to give briefly the results of observations made regularly with a pocket spectroscope, and to explain their value for meteorological uses. The conclusions derived are in the main similar to those already published by various authors;* it is hoped that their presentation in this form may secure the attention of some who are at present unfamiliar with the subject.

The aqueous lines of the spectrum are found principally in the red, orange, and yellow portions, and their appearance varies with the amount of aqueous vapor held suspended in the atmosphere at different times. The most prominent group is situated on the red side of the conspicuous D line, immediately adjacent to it, and is known as the "Rain-band." On account of its prominence and its variability under different hygrometric conditions, it is especially adapted for observations the aim of which is to note its intensity at different times, and to infer therefrom the relative conditions of the atmosphere with respect to aqueous vapor.

The accompanying chart, No. i., is designed to represent the appearance, under two widely different conditions, of that portion of the spectrum in which the rain-band is situated. The spectroscope used in making the observations from which the chart is derived consisted of a grating with 17,296 lines to the inch, and a telescope of 18 inches solar focus, with an aperture of 1⅞ inches. The position of the lines was determined by means of a scale reflected into the field of view and is intended to be only approximately correct. The upper half of the chart was made near noon, the image of the sun being thrown upon the slit by a porte-lumiere; the lower was made just before sunset, with the sun shining directly upon the slit. The additional lines shown upon the latter, and the increased heaviness of some, are due mainly, as has been shown by Janssen and others, to the aqueous vapor of the atmosphere. These effects are made apparent near sunset because the sunlight at that time reaches the instrument through a much greater thickness of the atmosphere than it is obliged to penetrate when the sun is high in the heavens. These lines are also more conspicuous the greater the amount of aqueous vapor existent in the atmosphere.† More extended charts of the atmospheric lines of the spectrum have been published by Angstrom, (see "Shellen's Spectrum Analysis,") by Hennessey in "Philosophical Transactions" for 1875, and by Janssen in "Annales de Chemie et Physique" for 1871.

* See articles by Professor Piazzi Smyth in "Edinburgh Astronomical Observations," vol. xiv.; "Nature," vol. xii., pp. 231 and 252; vol. xiv., p. 9; vol. xvi, p. 389; vol. xxii, p. 194; "Journal of the Scottish Meteorological Society," vols. ii. and iv.; "Knowledge," vol. ii., No. 48; "Madeira Meteorologic." which contains a comparison of results at Edinburgh, Lisbon, and Madeira. Also "A Plea for the Rain-band," by J. Rand Capron, Esq., in "Symons' Meteorological Magazine," Dec., 1881. In addition, there have appeared various articles in current periodicals.

† It should be noted that the chart does not represent the relative appearances of the rain-band in the same portion of the sky under different hygrometric conditions, but the relative appearances in two portions of the sky whose altitude differs greatly.

Viewed in a small pocket spectroscope, like the direct vision spectroscopes made by Browning or Hilger, this group of lines is reduced to a mere shading attached to the D line, varying in intensity with the altitude of that part of the sky examined; or, if the instrument is pointed always toward the same portion of the sky, varying with the hygrometric condition of the column of air through which light comes to the instrument. It is not necessary to point the instrument toward the sun, and, indeed, with a small spectroscope, it is better to obtain the spectrum from the sky itself. The observation consists in estimating the intensity of the shading under different conditions, and thus obtaining a rough idea of the hygrometric state of the air.

The plan adopted in making observations has been as follows :—

1. The spectroscope is directed to the sky near the horizon, and the intensity of the band estimated upon a scale of 5.

2. The spectroscope is then directed to the sky at an altitude of 45°, and a similar estimate is made.

3. The sum of the two readings is taken as the value for the observation, which is therefore upon a scale having 10 for its maximum. The observation at the altitude of 45° is quite as important as the one near the horizon. When the band decreases in intensity but little as the instrument is elevated from the horizon, it gives strong evidence of an undue amount of aqueous vapor in the upper atmospheric strata. It sometimes happens that the decrease is but slight, even to the zenith, in which case, except when this is caused by clouds, heavy rain is almost sure to follow.

Under ordinary hygrometric conditions at 7 a. m. in summer, I estimate 3 as the reading for the horizon pointing, and 2 as the reading for the 45° pointing. Thus 5 represents, upon my own mental scale, an average aqueous condition of the atmosphere at that hour, and readings giving greater values than 5 indicate an amount of aqueous vapor in the atmosphere above the average.

In order to illustrate the results obtained, I have selected the observations made daily at 7 a. m., at Washington, D. C., from July 1 to August 15, 1882. These are given in the form of a chart, No. ii, on page 18, which also contains, for the purposes of comparison, diagrams of the absolute and relative humidity obtained from the readings of a wet and dry-bulb thermometer, and of the rainfall. The observations were made with a Browning direct-vision spectroscope of five prisms, upon the plan outlined above. They have been entered upon the chart opposite their respective dates and connected by straight lines. It should be noted that the lines connecting the several observations of absolute and relative humidity, as well as of rain-band, do not represent the course of the humidity during the twenty-four hours of the day, but simply connect observations made at intervals of a day. The diagram illustrating the rainfall represents the rain recorded during the twenty-four hours between successive observations.

It will be seen from the chart that the following conclusions may be derived; they are justified by all the observations made, as well as by those of other observers that have been published :—

1. There is a general agreement between the rain-band curve and the curves of absolute and relative humidity. Such an agreement is to be expected if the rain-band indications have any hygrometric value.

2. Individual discordancies are often found between the respective curves. This is also to be expected, for if discrepancies did not exist there would be no advantage in the rain-band observations over those of the ordinary psychrometer. It is therefore necessary, in asserting that the former observations have an advantage over the latter, to point to cases in which this superiority is manifest. Two examples are indicated on the chart :—

(1) July 29: Rain-band, 6; absolute humidity, 8.1; relative humidity, 97. On this morning, rain had just ceased and the sky soon after cleared. The upper strata of

the atmosphere probably contained but little aqueous vapor, while the lower strata were nearly saturated.

(2) August 6: Rain-band, 4; absolute humidity, 8.8; relative humidity, 98. The absence of rain on this day indicates that the rain-band observation conveys a better idea of the hygrometric condition of the atmosphere, as a whole, than is given by the psychrometer.

A still better illustration is furnished by the following table, which gives the observations made through fog on the mornings of October 4–8, 1882. The relative humidity observed at 3 p. m., after the fog had cleared away, is added for comparison:

	Band.	*Rel. Hum.*	*Rel. Hum. 3 p. m.*
October 4, 1882, 7 a. m.	4	95	58
" 5 " "	4	95	56
" 6 " "	3	100	47
" 7 " "	4	90	55
" 8 " "	4	100	59

It will be noted that the relative humidity at 3 p. m. averages 41 per cent. below that at 7 a. m. The usual decrease in October at Washington between 7 a. m. and 3 p. m. is 28 per cent. The superiority of the rain-band observations in indicating the true humidity of the air is in this case evident.

3. The observations are not always satisfactory. If we compare them with the rainfall record it will be seen at once that the rain-band is not an infallible indicator of rain; thus the large rainfalls recorded on July 12th and 28th were not indicated by any of the hygrometric observations, with either the spectroscope or the psychrometer. The observation is also partially or wholly a failure, as far as forecasting rain is concerned, when the sky is covered with clouds; thus on August 12th, it was raining at the time of observation, and in consequence, both the rain-band and the humidity were high, but the sky cleared soon after the observation. There are also cases, as on July 8th, 9th and 10th, when an observation of the rain-band giving a value above the average, was not a precursor of rain.

The fact that it indicates the combined hygrometric condition of a large part of the atmosphere, and not of the lower portion alone in which the instrument is situated, constitutes the superiority of the rain-band observation. This great advantage is, however, in some measure offset by the indefinite nature of the observation itself. The rain-band is, under the most favoring conditions, quite small and faint, and therefore requires skill and experience in the observer to record its variations. In addition, there is no fixed scale by the aid of which the observer can estimate variations. Each observer is compelled to adopt for himself a mental scale which is liable to change somewhat from day to day. The scale will be different for different observers and different instruments, and, in consequence, there is difficulty in comparing the results obtained. It is probable that improvements in the spectroscopes employed will remove these disadvantages, in the event of which the superiority of the instrument for hygrometric observations will be much increased.

The exact significance of spectroscopic observations of the rain-band may be readily inferred from what has been written above. It may be summarized as follows:

The rain-band spectroscope is a form of hygrometer which gives a rough estimate of the aqueous condition of a large portion of the atmosphere. Its superiority over the psychrometer or other hygrometers is due to its power of taking account of the aqueous vapor present in the upper as well as in the lower atmospheric strata; but this advantage is partially neutralized by the uncertainties attaching to the method of observation.

The relation of observations of the rain-band to rainfall is found in the fact that the former indicates simply the *aqueous condition* of the atmosphere, but not necessarily

that this vapor will be precipitated. Precipitation depends upon several meteorological conditions, of which the quantity of aqueous vapor held suspended in the atmosphere is but one; it is this condition only which the spectroscope reveals, but a knowledge of the others is requisite for the forecasting of rain.

The rain-band observations are especially interesting to meteorologists because they are an attempt to obtain by instrumental means a knowledge of the conditions prevailing in the higher regions of the atmosphere. These regions are the seat of atmospheric disturbances whose presence is known chiefly by the variations of barometric pressure, and by the forms and movements of the clouds. An additional meteorological instrument is, therefore, supplied by the spectroscope, by which results of considerable value have already been obtained, and from which greater results may be hoped in the future. The observations have more value in summer than in winter, and are useful in anticipating local rains.

It should be borne in mind, however, that for the amateur, the observation with a small pocket spectroscope is not very easy, because of the minuteness of the band under the best circumstances. To this cause is probably to be attributed, the failure of some to obtain any results, and their consequent belief that nothing can be done with the instrument. Satisfactory observations can be secured only by a skillful observer. Even then, it must be admitted, that the observation is crude and superficial, and ought not to be regarded as the best that science can offer. With larger spectroscopes properly mounted, still more satisfactory observations have already been made than are possible with the pocket instrument, while the subject of atmospheric absorption, of which the rain-band is a small part, is today receiving considerable attention at the hands of spectroscopists.

SUGGESTIONS TO OBSERVERS.

The following suggestions are offered for the benefit of any who may attempt observations with the pocket spectroscope:

Special attention should be given to the focus and the adjustment of the slit. The ordinary solar lines that are visible must be made as black and distinct as possible. To secure this the colors of the spectrum must not be too bright. It is well to adjust the slit and the focus by successive trials until the solar lines are most clearly defined. The lines in the green (E and b) will aid in the adjustment, but the distinctness of the D line itself should be the final aim.

It is a good plan to shade the eye with the hand so that no light shall be received except that which comes through the instrument. A cloth thrown over the head, as is done by photographers, is a still better precaution.

If observations near the horizon and also at 45° altitude are to be made, the spectroscope should be elevated to an altitude of about 20° in adjusting the focus and slit. Then the readings of both points can be made without alteration of any adjustments. The spectral lines will not appear as distinct for higher altitudes as for lower.

The formation of the mental scale of comparison should receive careful attention. The maximum intensity must be determined by experiment. It may often be obtained from the western sky at sunset, or still better by examining the sky just before a heavy rain storm, or while rain is falling. Some observers adopt the scale 0 to 10, but it will be found that the scale 0 to 5 presents as many gradations as can well be estimated.

It is always preferable to make the observation in portions of the sky free from clouds. Aside from this precaution, the north or northwest sky may be selected.

If but one observation is possible daily, an hour between 7 and 10 a. m. should be chosen, but observations taken at several different times, as at 8 a. m. 12 m., and 4 p. m., are to be recommended. By all means, other meteorological observations

should be made at the same time. The most important of these are wet and dry-bulb thermometers, barometer, direction and velocity of wind, character and amount of clouds. Radiation instruments, if at hand, should also be read.

It is a good plan to attempt local predictions of "Rain" or "No Rain" in connection with the observations. These predictions should be based on all the weather conditions at hand rather than on those of the rain-band alone.*

In order to aid the beginner in acquiring information as to the appearance of the rain-band, chart No. iii. is given. This is reproduced from "Symons's Meteorological Magazine," for December, 1881, and illustrates the article by J. Rand Capron, F. R. A. S., entitled "A Plea for the Rain-band." The drawing was made with a more powerful instrument than the pocket spectroscope, but it gives a good representation of what may be expected in the latter. The rain-band is the shading at the left of the D line; the colors of the spectrum ranging from red on the left, to blue on the right. In a small spectroscope, the D line will appear single, and the maximum shading will hardly exceed that in (4). The following description of the drawing is taken from the article referred to.

By the term "low sun-band," is meant the band at the right of the D line. This is a variable band, but it is thought that it is not due to aqueous vapor. It is regularly observed by Professor Piazzi Smyth, together with the rain-band—

"To enable the observer to judge of the general appearance and intensity of the larger rain-band near D, I have given some drawings of spectra as seen in a spectroscope of small dispersion, of which the following is a discription:

"(1) Spectrum as seen upon a pure high sky, showing principal solar and telluric lines in their proper positions, and with their designations, but not showing the finer lines between, nor any bands.

"(2) Spectrum observed January 17, 1881, 8 a. m. Morning dull; red sunrise; low sun-bands and lines (note especially band to right of D) strong. *No* rain-band.

"(3) Spectrum observed August 24, 1881, 8 a. m., showing moderate low sun-bands and lines, and a *faint* rain-band, with rain lines showing through.

"(4) Spectrum seen November 16, 1880, 1 p. m. Rain and wind, but clearing in some parts of the sky. Low sun-bands and lines weak. Rain-band *moderate.*

"(5) Spectrum seen December 9, 1880, 8 a. m. Sun shining through watery clouds. Low sun-lines strong. Rain-band *strong.*

"(6) Spectrum seen July 6, 1881. Rain-band everywhere, and *exceptionally* strong, stretching nearly half way between C and D. Whole spectrum darkened and obscured.

"The above-described drawings do not give, except in a rough way, the details of the lines and bands other than the rain-band, which is situate to the left of the double line D, and has its place marked by an R."

Of the works upon this subject none have been written, as far as I have learned, by other than English authors. The most important of these are found in the "Edinburgh Astronomical Observations," vol. xiv., by Professor Piazzi Smyth, and in "Symons's Meteorological Magazine" for December, 1881, by J. Rand Capron, F. R. A. S. The latter is issued as a separate pamphlet by John Browning, of London, and accompanies his "Rain-band Spectroscope." Works on spectrum analysis, by Schellen, Roscoe, and Lockyer may also be consulted with advantage upon the subject of atmospheric absorption.

*Out of 49 predictions made at 7 a. m. of "Rain," or "No Rain," for the succeeding twenty-four hours, based upon the rain-band alone, 34, or 69 per cent. were verified. Out of 49 similar predictions, taking account of all known weather conditions, 41 or 84 per cent. were verified.

Chart No I.

Lines in the Spectrum comprising the Rain Band.

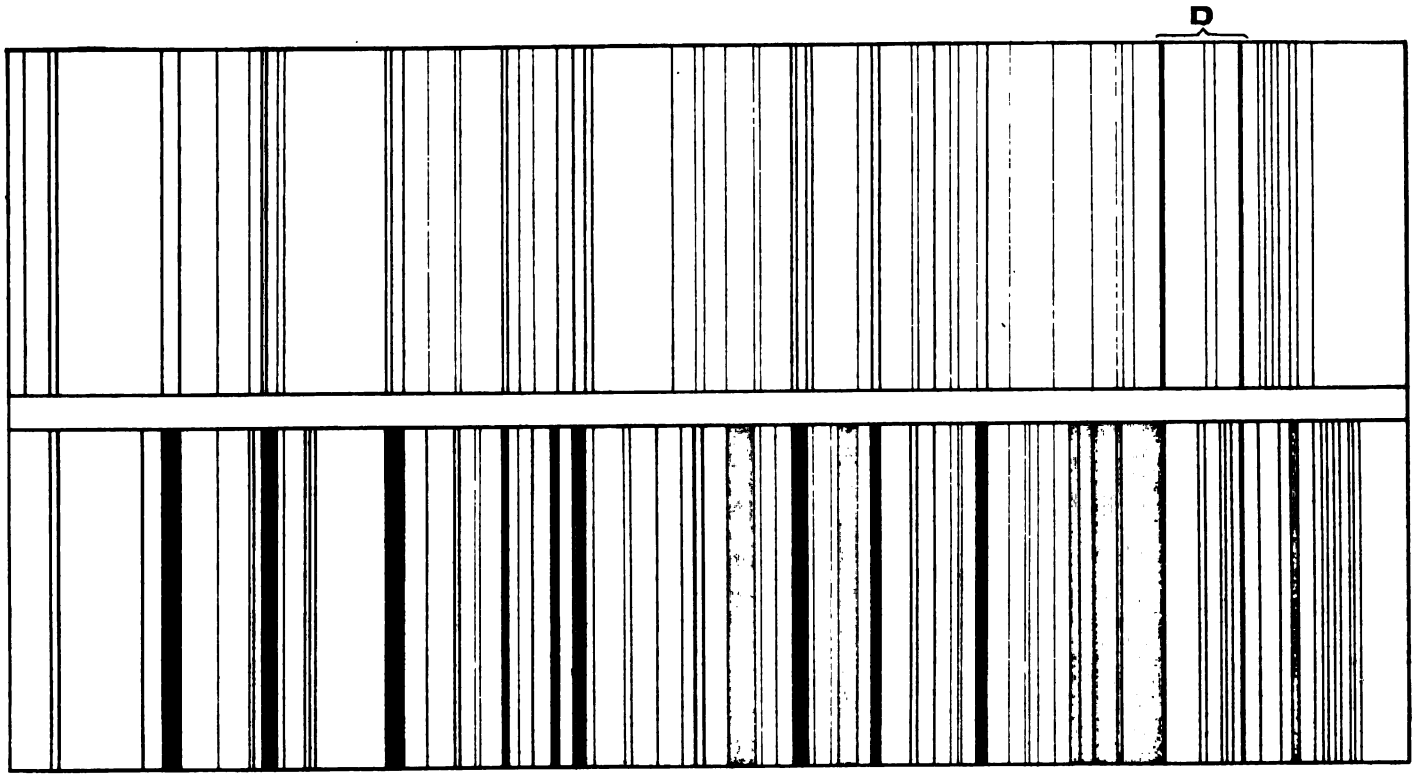
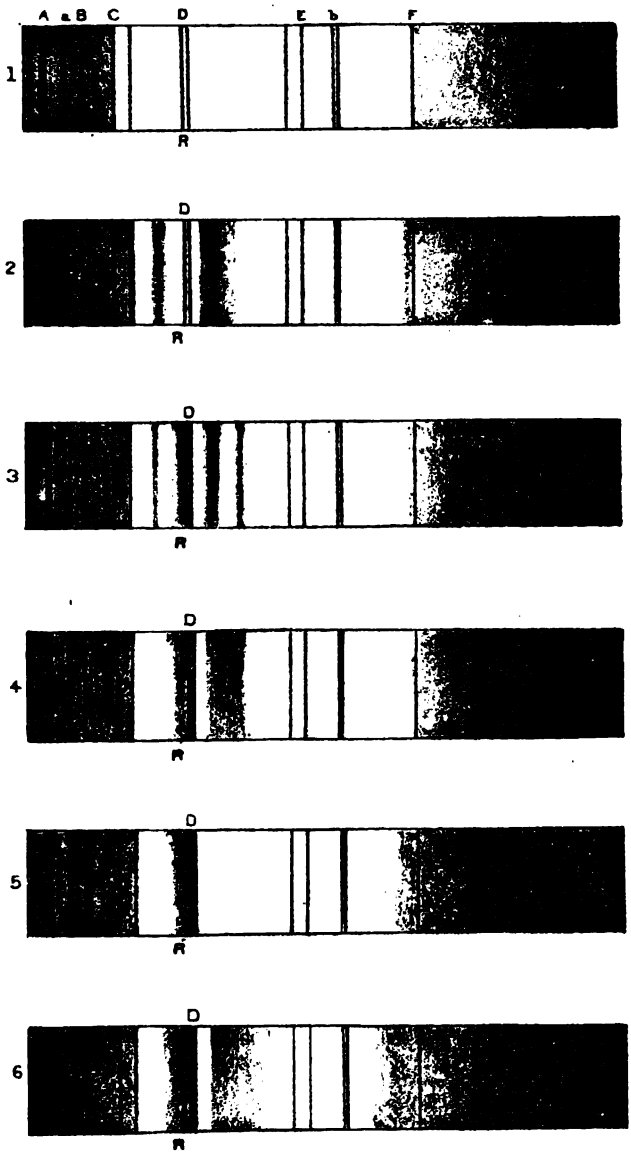


Chart No 2.

Rain Band Observations from July 1. to Aug. 15. 1882, made at Washington, D.C.

From Symon's Monthly Meteorological Magazine, Dec. 1881. *Chart No. 3.*

THE RAIN BAND IN SPECTROSCOPE
OF MODERATE DISPERSION.



UNITED STATES OF AMERICA:
WAR DEPARTMENT.

SIGNAL SERVICE NOTES

No. V.

WORK OF THE SIGNAL SERVICE

IN THE

ARCTIC REGIONS.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY.

BY AUTHORITY OF THE SECRETARY OF WAR

WASHINGTON:
OFFICE OF THE CHIEF SIGNAL OFFICER.
1883.

UNITED STATES OF AMERICA:
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No. I.

REPORT OF MR. W. M. BEEBE:

RELIEF EXPEDITION TO LADY FRANKLIN BAY, GRINNELL LAND.

SAINT JOHN'S, N. F., *September* 28, 1882.

To the CHIEF SIGNAL OFFICER, U. S. A.,
Washington, D. C.

GENERAL: I have the honor to report that in obedience to orders contained in your instructions dated "Office of the Chief Signal Officer, Washington, D. C., June 18, 1882," I assumed charge of the men and supplies for Lieutenant Greely's party, Discovery Harbor, Lady Franklin Bay, Grinnell Land, upon their arrival, on the "Alhambra," from New York, on the morning of July 4th. These supplies, and those ordered to be purchased at Saint John's, were loaded on the "Neptune" with as little delay as possible, and the party sailed at 1.30 p. m. on the 8th.

Your instructions regarding observations to be taken on the voyage were duly turned over to Captain Sopp, of the "Neptune," but, as the instruments intended for this purpose could not be found, and as Captain Sopp evidently did not understand the nature of the observations ordered, I transferred the duty to Private Joseph Palmarts, Signal Corps, U. S. Army; the results of his work with such instruments as the ship afforded, from the 13th of July until our return to Saint John's, are herewith submitted, marked "A." They are the means of eight observations taken each day.

During the first few days of the voyage, heavy winds and a rough sea were experienced, and our party were confined to their berths by sea-sickness. On the morning of the 12th, the weather moderated and the sea went down rapidly; since that time the health of all on board has been good. At 6.30 p. m. of the 12th, in latitude 55° 3′ N., longitude 51° 25′ 45″ W., we spoke the Hudson's Bay Company's steam-yacht "Diana," from London, England, to Ungava bay, Labrador, requesting to be reported by the first return vessel.

On the morning of the 13th of July, the first field ice was encountered 135 miles due west from Cape Farewell, latitude 60° N., longitude 54° 50′ W.

The fields, though not large, were very heavy and solid. Undoubtedly this was the heavy winter-ice, borne from the eastern coast of Greenland by the strong current which sets southward from about Iceland, turns to the westward and northward around Cape Farewell, and flows up the western coast of Greenland, until, in latitude (about) 67° N., it meets and mingles with the current from Baffin's bay. These united currents set southward with great strength down the coast of Labrador, and, trending eastward, pass around and down the eastern coast of Newfoundland and into the Gulf-stream, carrying with them the immense icebergs launched from the numerous glaciers of west Greenland and so much of the field ice as has survived the passage from Davis strait.

Our passage during the 13th did not exceed three miles an hour, but the ship gave

evidence of her great strength, and her fitness for the work before her, breaking with ease and pushing aside the fragments of solid ice "pans." At 7.30 p. m., a dense fog having settled upon us, the ship was moored to a convenient ice-pan, to await clearer weather.

At 3 o'clock on the morning of the 14th, the lines were cast off, but it was evening of the 15th before the pack was finally cleared. During the day, a three-masted schooner was sighted standing in toward Holsteinburg, and at 9 o'clock in the evening we came up with the American schooner "Concord," of Gloucester, Massachusetts, at anchor, fishing for halibut, which are taken here in great numbers and are of superior quality.

We reached Godhavn at 5.30 on the evening of the 17th, and I went immediately on shore, accompanied by Doctor Hoadley and Captain Sopp, to pay our respects to the Inspector. I report with regret the death, on the 27th of May, of Inspector Smith, whose interest in all American expeditions to the Arctic regions is well known to you.

Mr. Kneuthsen, the acting inspector, and the governor of Disco, Mr. Djurhnüs, received us with great kindness, and during our stay did all in their power to aid us in securing such articles required by Lieutenant Greely as had not already been prepared in compliance with your request. The order for sleeping-bags had been received so late that material suitable for their manufacture could not be obtained, but through the courtesy of the officials, four (their individual property) were secured. All other articles ordered through the Danish Government had been collected in the quantities desired, with the exception of "matak," of which but sixty-four pounds could be obtained, and this, as it afterwards proved, had not been thoroughly cured, so that, notwithstanding the care given it, it soon became worthless.

I was unable to comply fully with your orders to pay for all stores purchased in Greenland, as I have explained in a former brief report.

We left Godhavn on the evening of July 20th, and on the morning of the 22d, again met field ice, neither so heavy nor so firm as that previously encountered; the ship worked her way through it readily at half-speed. The weather was disagreeable with rain and sleet, but it cleared sufficiently at noon to enable the captain to ascertain our position, latitude 73° 4′ N., longitude 58° 39′ W. During the afternoon, the ice became firmer and more closely packed. At 8 o'clock in the evening, a blinding snow-storm came on. This rendered it impossible to pick our way through the channels, and it was found necessary to again tie up to an ice-field, where we remained during most of the night.

Fair progress was made during the morning of the 23d, but at 1 o'clock p. m., we were again stopped by ice, through which the ship could not be forced; it extended in our front to the horizon. During the afternoon, a slight opening occurred, through which the ship worked with difficulty, but at 8 o'clock in the evening, we were again stopped and fairly "beset," being unable to move in any direction until midnight, when the strong north wind again freed us, and slow progress was made until 2.30 p. m. of the 24th, when, in latitude 75° N., logitude 60° W., we were again stopped. On the 25th, and until 7 o'clock a. m., of the 26th, we remained helplessly drifting with the tides, within plain view of Cape York, with its numerous glaciers, and the Crimson Cliffs of Beverly.

The weather had continued foggy, giving us only occasional glimpses of the sun, but on the 28th, it became clearer, and for the first time the sun was seen shining brightly at midnight.

Followed all day by half a gale of wind on the 28th, the ship made fair progress, passing Westenholm island at 8 o'clock in the morning, and Cary islands about 7 in the evening. At 3.30 on the morning of the 29th, Littleton island was passed, but half an hour later I was called by Captain Sopp and informed that we could go

no further. Going at once on deck, I found an unbroken ice-barrier, from twelve to twenty feet thick, extending from Cape Inglefield on the west across the sound to Rosse bay and to the northern horizon, effectually checking our further progress. The ship was therefore turned southward, and looked in at Life-boat cove and at Port Foulke; a comfortable anchorage was at length found in "Pandora" Harbor. This harbor, named by Sir Allen Young, is a beautiful bay shut in by the Crystal Palace Cliffs upon the south, Cape Kenrick on the north, and by lower and less abrupt hills upon the eastward. During most weather, the anchorage would be a safe one, but during our stay there of a week, riding out a succession of southwesterly gales, much trouble was experienced, one anchor being lost, and two heavy hawsers, warping the stern of the ship to the rocks, were parted.

While here, Sir Allen Young's record of the "Pandora" was found, near the water's edge, where it had been washed down from the cairn upon the summit of a low point of rocks. This record, together with a copy of my own, which was left in the cairn is attached, marked "B."

Game was found in abundance. Arctic hares, the eider-duck, auks, and several varieties of gulls, of which a two week's supply for all hands was brought in by the hunting-parties, and proved a most acceptable change from the ordinary ship's fare. Several reindeer were seen, but none were taken.

On Monday morning, August 7th, the water-casks were filled, and at 10.45 we resumed our way northward. Heavy ice was soon encountered, but the fields which had been quite thoroughly broken by the southwest gales, were small and easily avoided, becoming larger and more compact, however, as we advanced, until at 9.45 p. m., we were compelled to stop and tie up to a large floe off the northern point of Bache island. The ice continued to close in upon us rendering movement in any direction impossible, and on the morning of the 9th, we found the ship fairly "beset" and helpless, twelve miles from Victoria Head, the nearest point of land. Toward evening the larger fields closed in more rapidly, rendering our position extremely perilous; the ship was raised bodily three feet, and the creaking of timbers and the grinding of the ice as it pressed upon her sides were ominous sounds. Had it not been for the smaller and softer ice immediately about us, and which, crushed by the solid fields as they closed us in, formed a cushion underneath the hull, the strong ship must inevitably have been crushed.

On Thursday, the 10th, we drifted a short distance northward, and reached the highest point attained, latitude 79° 20′. We were twelve miles from Cape Hawkes and seventeen from Cape Prescott, the intervening ice being impassible for even an unencumbered man. The season was still young and all on board were sanguine that a northerly wind would soon start the ice and that Discovery Harbor might yet be reached.

On the 11th, the ice closed in more firmly, piling the broken fragments as high as the bulwarks.

On the 12th, the wind subsided somewhat and the ship once more rode upon an even keel, but still three feet above the proper level.

At midnight I was on deck with the first mate, when a gentle crackling of the young ice attracted our attention, and, by the bright sunlight, we could see the water slowly trickling through. At 7 o'clock, a slight opening was observed between the large fields which had held us fast, and with great difficulty the ship was forced into open water to the southward. So great a power was found necessary to force our way that the boiler was overstrained and sprang a leak. This added greatly to our anxiety.

Your attention is respectfully invited to the accompanying chart (marked "C") made by Private Francis Thoma, 5th Infantry; it illustrates the movements of the ship in our search for a practicable route.

Upon reaching open water on the 15th of August, we stood across the sound to the eastern shore, but found no opening, and concluded to endeavor to secure an anchorage, from which to watch the movements of the ice, so that we might be prepared to take advantage of the first opportunity to reach Cape Hawkes, at least, where I had determined to establish, at once, the depot "A," and leave the whale-boat specified by Lieutenant Greely, which could be removed and taken further north should opportunity occur.

At one o'clock on the morning of the 18th, a comfortable anchorage was found in Payer Harbor, latitude 78° 42′ N., longitude 74° 21′ W., between Cape Sabine and Brevoort island, where the "Alert" and "Discovery" remained for a few days in 1875.

In a cairn on the summit of Brevoort island, Captain Nare's record was found; it accompanies this paper (marked "D,") and on a long, low, island near to and due west (true) from Brevoort island were found a small depot of provision left by the "Discovery," and the accompanying statement of Captain Stevenson.

The depot consisted of one barrel canned beef; two tins, forty pounds each, bacon; one barrel, one hundred pounds, dog biscuit; two barrels, one hundred and twenty rations each, biscuit: all in good condition; two hundred and forty rations, consisting of chocolate and sugar, tea and sugar, potatoes, wicks, tobacco, salt, stearine, onion-powder, and matches, all in fairly good condition.

Three small casks that had contained rum and high-wines were separated from the other packages, broken, and their contents evaporated or leaked out. There was also found the remains of an Esquimaux skin-boat, or oomiak, utterly destroyed, the frame broken and bearing marks of the teeth of some large animal, while the remnants of skin remaining fastened to the keel bore similar evidences of having been destroyed by bears.

The cache was rebuilt and made as secure as possible, marked by two oars, found with the depot, placed upright in the rocks, and a record of the "Neptune" placed in the cache. A description of this depot and its position was afterwards left with the depot established on Cape Sabine.

During the 21st and 22d, ice was observed in small quantities passing down the strait, but a visit to the summit of Cape Sabine, which was accomplished after severe climbing, did not afford much encouragement. However, as the ice, broken by the southwest winds, which had blown with considerable force for two days, seemed passing steadily down, I urged the captain to move out on the morning of the 23d. We started at 1.30 p. m., and found the western shore effectually blockaded above Cape Sabine, but standing to the eastward again found comparatively open water in mid-channel, through which we worked our way to a point nearly due east from Cape Prescott, where heavy, unbroken ice, extending as far as the eye could reach to the northward and from shore to shore, was encountered.

I now determined to turn all my attention to efforts to land supplies and whale-boats as far north as possible. Lest it should be found impossible to reach land with the boats, I caused a large sledge to be made, loaded with the boats and stores, which might be hauled by my party and volunteers from the ship's crew, over the ice if that should be found practicable.

Turning again to the westward, when our progress to the northward had been checked, we stood along the unbroken edge of the solid ice, and at 10 o'clock p. m. were again nearing Cape Sabine, without having found a crack in the solid pack, while the entrance to Payer Harbor was blockaded. It was now necessary to find an anchorage as the southwest wind, which had held in that quarter almost without interruption since our arrival in Smith's sound, was increasing in force, and the ship was headed for Littleton island. The captain was, however, not satisfied of the safety of the small harbor there, and, declining to take soundings and seek an anchorage in Foulke Fiord (which Captain Nares recommends as a winter harbor), continued

down to Pandora Harbor. There were already many evidences of approaching winter. The vegetation, bright and green on our departure on the 7th, was faded and brown, the flowers had disappeared, the ducks had taken their departure southward, and the summits of Cape Kenrick and Crystal Palace Cliffs were covered with snow.

Fully impressed with the great importance of establishing a depot as far north as Cape Hawkes, and fully satisfied that whatever was to be done must be accomplished quickly, we left Pandora Harbor at 3 o'clock on the afternoon of the 25th, but at half past nine were again brought to a check in the pack and compelled to tie up to an ice-floe.

During the 26th, a little gain to the northward was made, but we were again checked by an impenetrable pack forty miles from Cape Hawkes.

The edges of the heavy fields of intervening ice, crushing together with every change of wind and tide, were thrown up in huge, irregular rifts, impassable, even had they been stationary, by the trained seal-hunters who composed our crew; the idea of landing the stores by means of a sledge and boats was therefore abandoned.

On the 27th, we were able to move some distance to the northward, again reaching a position off Bache island, but no nearer land than we had been before. The wind freshening from the northwest, the ship was made fast to the floe to await the opening which was confidently expected. Notwithstanding the direction of the wind the larger fields, many miles in extent, moved westward against it, when, coming in contact with the land, their course was changed to the southward until checked again by Cape Sabine and Brevoort island.

All the ice in Smith's sound seemed drifting southward bodily, and it was determined to stand across once more to the eastern side, with the faint hope that a channel might be found where the fields had broken from the solid ice above, and by which the western shore might be reached.

The ice was close in shore, and our course was again changed to the westward, skirting the solid pack, the captain pushing the ship into every channel leading towards Cape Hawkes with all the energy that could be desired.

The western shore above Cape Sabine was unattainable, and fearing that Littleton island would soon be closed to us, I determined to establish the cache directed to be made there, while awaiting an opportunity to reach some point on the other side. New ice was forming every night and the captain became anxious for the safety of the ship; therefore, although determined to remain as long as there was the slightest hope of carrying out the letter of my instructions, and to retreat only when compelled by lateness of season, I was fully satisfied that we could stay but a few days longer in these waters.

On the 28th, there was a heavy southwest wind and snow. At 7.45 p. m., we anchored off Littleton island, and early on the morning of the 29th, the wind having subsided sufficiently to admit the landing of a small boat, I went on shore to select a place for the cache, when our presence was discovered by a party of Etah Esquimaux upon Cape Ohlsen. Crossing over I found it to be a hunting-party of six men and three women, who desired to accompany us on board the ship.

Regarding it unwise if not useless to land stores upon Littleton island while the natives remained in the vicinity, and thinking that a landing might be effected on the opposite or northern end of the island at night without their knowledge, we again stood across the channel, and at 1 o'clock on the morning of the 31st, succeeded in effecting a landing and establishing a cache upon Cape Sabine, the northernmost land that had been attainable by us. The stores and whale-boat were placed in a sheltered spot, well secured and covered by a tarpaulin. A tripod made of scantling, with an oar attached, to which pieces of canvas were well nailed,

was placed upon a prominent point, showing well from the northward and securely anchored with rocks, and in a cairn beneath was placed a record giving the bearings of the cache. A copy of this record is attached, marked "D."

A heavy northeast gale coming on, we took temporary refuge under the lee of Cape Ohlsen, a comfortable and safe anchorage in a north or northeast wind.

The Etahs paid us another visit and I determined, should it be necessary and as a last resort, to take them to Pandora Harbor and leave them.

The gale continued unabated during the 1st and until noon on the 2d of September, when we left our anchorage for a final effort to get further north.

Heavy field ice was met off Cape Sabine, increasing in size and thickness as we proceeded, until the captain positively refused to penetrate further, and, at 8 o'clock in the evening, made the ship fast to an ice-field. At 9 o'clock, new ice, cementing the broken floes, had formed to the thickness of three inches.

On Sunday, the 3d, we remained all day tied to the ice, shifting our position as safety from floating masses demanded, and on Monday, the 4th, finding it impossible to advance, the new ice having increased to four inches in thickness, and the engineers having reported a leak in the boiler, which up to that time had been kept from my knowledge, I determined to establish the cache on Littleton island without further delay. The natives still remaining on Cape Ohlsen, the stores were landed in a cove at the north end of the island, so well concealed as to be invisible from any point a few yards distance, and covered with a "paulin," securely anchored down with rocks, while copies of record, with minute directions for finding the stores, were placed, as directed in Lieutenant Greely's letter of last year,—two in the coal at the southern end of the island and one in Nare's cairn on the summit of the southwest part of the island. A copy of this record is attached, marked "E."

As a last resort, the remaining whale-boat was placed on Cape Isabella, and its location marked by a tripod showing well to the northward.

Should Lieutenant Greely's party reach Cape Sabine next year, before the arrival of the relief ship, they will scarcely fail to find this boat.

I then called a consultation, requesting an expression from Dr. Hoadley, Mr. Norman (the 1st officer), and Captain Sopp, who were unanimous in the opinion that further delay was useless and extremely hazardous; that everything had been done that could be done to carry out your orders; and that the safety of the ship and the lives of all on board demanded an immediate departure. At 11.40 on Tuesday night, I gave a reluctant assent and the voyage homeward began.

No field ice was seen after leaving Smith's sound, but icebergs in great numbers and of unusual size were encountered in the vicinity of the Cary islands, and for two days after passing that point.

We reached Godhavn on the evening of September 8th, and satisfactory arrangements were made for leaving the dogs, dog-food, and lumber. I made an unofficial request upon the acting inspector to have in readiness for next year's expedition, such additional dogs as may be needed, also skin-clothing, two or more dog-sledges, and two native drivers, stating that an official request would be made through the Danish government by the Chief Signal Officer of the Army.

A week's delay was found necessary by the captain for making repairs to the boiler, taking on of ballast, and such refitting as was needed for the homeward voyage.

Tiltcove, Newfoundland, was reached on the 23d, where I telegraphed you of our safe arrival and the failure of the expedition, and on Sunday, the 24th, at 10.30 p. m., Saint John's was reached.

Some delay was experienced in securing a store-house, where the supplies would be safe from frost and vermin; this was, however, finally secured, and the stores landed, but, transportation for all my party (including myself) having been ordered

by the "Alhambra," I was compelled to leave Saint John's without receipts. These will, however, reach Washington by next mail.

I take pleasure in earnestly recommending that the services of Doctor Hoadley should, if possible, be secured for the expedition to be sent next year. In addition to his professional fitness, he possesses physical strength and experience in travel, which eminently qualify him for the duty. I also take pleasure in testifying to the good conduct and cheerful performance of duty by the enlisted men of the party, and recommend that they all be allowed to accompany the next expedition.

I am, General, very respectfully, your obedient servant,

W. M. BEEBE, Jr.

No. II.

REPORT OF LIEUTENANT JOSEPH S. POWELL:

RELIEF EXPEDITION TO POINT BARROW, ALASKA.

WASHINGTON D. C., *December* 5, 1882.

TO THE CHIEF SIGNAL OFFICER, U. S. A.

SIR: I have the honor to submit herewith, the following report relative to the relief expedition to Point Barrow, Alaska, placed under my charge:—

The schooner "Leo," of 150 tons burden, having been chartered by the government for the purpose, sailed from San Francisco, California, at 8.30 a. m., June 24th. We encountered head-winds and half gales during the passage over the Pacific. No incident of importance occurred until July 14th, when land was sighted, which proved to be the Shumagin islands, bearing ne. from Unimak pass, in longitude 160° W., latitude 55° N. After sighting these islands, the ship was tacked to the southwest, and on the 19th of July we reached the pass, but were prevented from clearing it by head-winds until the 20th. Our position in the pass on the night of the 19th, was rather dangerous. A heavy fog settled down toward night, turning into rain with a heavy sea, rendering it impossible to see land, and the only course left us was to beat forward and backward within the narrow limits of the pass, by the clock, until morning. The distance between the islands is but seven miles, and the land rises almost perpendicularly on each side. After clearing the pass on the 20th, the wind hauled to the southeast and blew a gale.

The cook having been taken seriously ill after the first ten days out, it became necessary to secure some one in his place, and with that end in view the master of the vessel endeavored to make Saint Paul's island, but we were not successful, owing to the gale before mentioned. I then directed that we proceed to Saint Michael's, a station of the Alaska Fur Company, with the hope of securing a native. We reached Saint Michael's July 26th, and after considerable persuasion, shipped a native named Kan-u-ark as cabin-boy. One of the principal objects I had in view in selecting this native was, in case we found it impossible on account of ice to reach Point Barrow, to have him act as interpreter and messenger.

Judging from the name, one would suppose that some sort of a colony was located at Saint Michael's, but such is not the case. The only whites at this place are the agent of the Alaska Fur Company, his wife and one assistant, together with the United States weather observer. As the vessel sailed into the harbor we were greeted with a salute by mountain-howitzers.

As before stated, considerable difficulty was experienced in securing a native. The news of the loss of the "Jeannette" had already reached the people and consequently they seemed loth to venture abroad in the white man's ships, which were thus liable to sail away and never return. The savage man all the world over is extremely prone to superstitious fears, and it is not at all to be wondered at that the simple native of these shores should be considerably impressed when he sees the mighty "Oomiaks" of the white man go away in the gloom of the mysterious north

and return no more. A jealous spirit seems to the poor native to reign over these gloomy solitudes, who will not permit the secrets of his realm to be explored with impunity, and when the mighty "Tungah" seizes upon the large vessels of the white man and dashes them to pieces in his anger, terror thrills through the poor savage, and he refuses to venture within the reach of the baleful power of the icy north, so potent for evil.

Kan-u-ark understood a few words of English and proved tolerably handy in waiting on the table, etc., although such employment must have been a new experience to him. We left Saint Michael's on the morning of the 27th and sailed for Golovin bay, directly opposite, where we took in a supply of water. Owing to heavy gales on the outside, we laid in this harbor two days and then sailed for Point Barrow. On reaching Behring sea we encountered a heavy gale from the north, with weather so thick as to prevent making any headway toward the straits. Finding it impossible to make northing and the gale increasing, I directed that the vessel proceed to Plover bay, having by this time become aware that with a sailing vessel we might be unable to make this point on our return. Weather still continued thick, and having proceeded in the direction of Plover bay as far as it should lie as registered by log, the vessel was hove to, waiting for the fog to lift that bearings could be taken. We laid there two days without a sight of land or of the sun, but on the morning of the third day it cleared sufficiently to distinguish the land, and we found ourselves about four miles from the entrance of the bay. On this morning, the wind, which had been blowing steadily from the north ever since we left Norton sound, lulled almost to a calm.

A steamer was sighted in the morning bearing down on us, and made out to be the U. S. revenue-cutter "Corwin;" to the captain, J. T. Healy, I am much indebted for courtesies. She came alongside and towed our vessel up the bay. Anchor was dropped at 1 p. m. At this hour the sky was clear, but the time too early for taking observations for rating chronometers in this latitude. At 2.30 p. m., I found the sky becoming overcast, with every appearance of another gale, and made all haste for taking such observations as could be had. It became foggy and cloudy in a short time, and but two observations of any value could be secured. The captain of the "Corwin" informed me that he would leave at 6 p. m. and would tow our vessel out if we were ready, and also that I could consider myself fortunate in securing the observations I had, as, at this season of the year, it was liable to be foggy or cloudy for a week at a time.

After considering the advantages of his offer, and there being every evidence of a long duration to the cloudiness, I accepted it. In order to check the observations taken on shore, I had comparisons made with the chronometer on board the "Corwin," believing that good results could be obtained, as this steamer was only three weeks out from San Francisco, and her chronometer properly rated.

The observations taken at Plover bay, though the number is small, are considered as very good, and are contained in an appendix to this report.

It became evident, after leaving Plover bay, that the opinion formed as to a lengthy continuance of cloudy weather was correct. Outside of the bay we laid in a calm until 8 p. m. August 7th. All this time the fog grew denser, to such an extent that we could not see a ship's length ahead. At the above-named hour a breeze sprang up from the south, and gradually worked itself into a gale. All day it continued, and increased in violence during the night, with no appearance of the fog lifting. The next morning, land could be distinguished through the fog, dead ahead, and not distant over two miles, and seemed to extend to the east and west. The master of the vessel imagined he was still on the Siberian coast, and the bluff we saw was the south head of Saint Lawrence bay, and that our position was due to a strong current moving to the northwest. The gale had so increased that it be-

came necessary to close-reef the sails. Then it became apparent that we were drifting ashore, and our only hope was to weather the point of land lying to the east, believing, if this could be done, we would find refuge in Saint Lawrence bay. It seemed an almost hopeless attempt, as we kept drifting nearer and nearer, but at last were successful in weathering it, though our distance from shore was less than one-half mile.

Our disappointment was great when we discovered that the land on the other side of the bluff trended toward the northeast, instead of to the northwest, as we expected it would. We kept on a course about southeast, until near dark, when low land was discovered right ahead. The chart and log-book were consulted, and it was clear to my mind that, owing to the foggy weather and a sailor's natural timidity of land, we had made more easting than should have been done, and the land we saw in the first instance, was a small bight between Cape Prince of Wales and Cape York, on the Alaska side, and the low land a portion of the spit at the entrance of Port Clarence.

It being considered impossible to again weather the bluff, we had been working around all day, I instructed the master to endeavor to make the harbor of Port Clarence, which was accomplished at 10 p. m., and anchor dropped. The making of this harbor I consider quite fortunate, for the gale increased in fury, and had we still been exposed to it, off a lee-shore, as we were earlier in the day, I am afraid the "Leo" would have ended her voyage then and there, and all on board gone to the bottom. The wind was estimated as blowing seventy miles an hour, and the sea running so high that had the ship struck, she would have been dashed to pieces in a few minutes, and no one could have reached the shore alive. The storm was a very extensive one, and continued till the 11th; the barometer in the mean time going down to 29.20. We remained at anchor three days, and then started on our way to Point Barrow. We passed through Behring strait on the morning of the 13th, and crossed the arctic circle at 12 m., same day.

Cape Lisburne, the northwestern point of America, was sighted on the 14th, and the next day a heavy gale struck us from the east, in the face of which we were unable to make more than ten miles in the next two days. At 12 m. August 18th, we were in a calm, in longitude 158° 50′ W., latitude 71° 21′ N. At 8 p. m., a breeze sprang up from the southeast and we headed for the station, only one point out of our course. At this time we were only forty-eight miles from Point Barrow, and in nearly the same latitude, and supposed with the four-knot breeze blowing we would be able to see the point about 6 a. m. next day. At that hour next morning, a sight was had of the sun and latitude approximated, and found to our surprise we were considerably to the northeastward of Point Barrow in longitude 155° or less (dependent upon latitude), and latitude assumed to be 71° 30′; though afterward it was determined it should have been much more. We were surrounded by ice-floes, and to the eastward could see the old ice-pack. Our position was determined to be the result of the action of a strong northeast current. This was verified by Lieutenant Ray, with whom I conversed about the matter, and who stated that there is a strong current moving past station to the northeast at a velocity of from two to three knots an hour, and that our vessel was in rather a dangerous position, for should it have become calm, we should have drifted to the northeast, beset with and crushed by ice; that vessels caught in this current move off to the northeast and not a piece of timber ever returns.

We came to anchor Sunday, August 20th, at 8 p. m., off the station at Ooglaamie. On the 21st, the wind blew so strongly, and the surf was so high that the landing of supplies, or even boats, was out of the question.

During the time we were landing supplies, all station instruments were compared with the standards I carried with me for this purpose.

Lying, as we were, in an open harbor, with every probability of a gale, which would have caused our weighing anchor and standing out to sea, and not knowing when we could ever return, I believed it to be my first duty to land all supplies. Officers, enlisted men, and natives performed their share of labor, and I believe it was owing to the energy displayed by the party at the station, that we were saved from a gale which commenced the morning after we sailed, and would undoubtedly have beached us or blown us so far to sea that the chances of returning would have been small. We began the work of unloading Tuesday, though the surf was still high. Wednesday and Thursday this work was continued.

On Thursday, the ice, in extensive fields, began moving rapidly to the southwest quite close to the vessel. Thursday night, ice came into contact with vessel, but no damage resulted save a bad shake up. Friday opened with a half gale, accompanied by snow. Saturday, same condition as on Friday. All work was suspended on these two days. Heavy ice closing around vessel and sharp lookout kept for the old pack, the approach of which, the fields and small bergs were sure indications. Sunday, the landing of supplies was finished, and after receiving mail on board, &c., we weighed anchor homeward bound at 2 p. m.

By reason of certain facts, which I have explained to the Chief Signal Officer, an official inspection of records of station was not made, so that a report relative thereto is not possible. From personal observation, and from conversations with Lieutenant Ray, I feel safe in asserting that the work is conducted in a highly creditable manner, and more accomplished than was considered could be, taking into consideration all the difficulties which had to be encountered and overcome. The success of this expedition is due solely to the energy, intelligence, and indefatigable labor of Lieutenant Ray.

The magnetic instruments in present use are the Unifilar (Declinometer) Dip-Circle and Bifilar, and all are properly adjusted.

The dip-circle has been used for absolute determinations, I presume, on "term" days, and weighted and used as a differential instrument the remainder of the month. The value of the weight, Lieutenant Ray informed me, is known. He also informed me that all readjustments have been computed and preserved.

All buildings about the station are substantial, and the dwelling-house is very comfortable. No sickness occurred during the winter; this, I believe, was due to the stringent rules enforced by Lieutenant Ray relative to exercise.

During my stay at the station, I had comparisons made daily, whenever landing could be made, with chronometers on shore. For this purpose, number 1692 was used as a "Hack." This instrument was handled carefully, and but small variations occurred by transporting it. There was but one day on which the sun shone sufficiently to make observations. On this day twelve sights were secured at different intervals. All observations and comparisons of chronometers going from and returning to San Francisco are embodied in a separate report. These observations and reductions were placed in the hands of Mr. Winslow Upton, computer, O. C. S. O., who has corrected all errors, and submitted a report of final result, which I embrace in this report as an appendix.

But little time was afforded me for familiarizing myself with the country or the customs and habits of the natives, and to Lieutenant Ray and Sergeant Cassidy I am indebted for valuable information, not only in this connection, but of the work performed during past year.

The winter had been long and severe, but hardly so much as had been expected. After the expedition arrived in September, 1881, a dwelling-house and observatories were at once erected, and on the 17th of October, hourly meteorological observations began, and hourly magnetic on the 1st of December, and from that time no interrup-

tions in the work have occurred. The magnetic work was especially trying during the very cold weather, for delicate instruments had to be manipulated and read in temperatures sometimes as low as —45°. At such times it was almost impossible to touch brass or other metals with the ungloved hand. From the 1st of December, 1881, to the 1st of August, 1882, over 90,000 readings of the magnetic instruments alone were taken and recorded. A corresponding amount of meteorological work was carried on at the same time.

The station is located on Cape Smyth, on a low ridge, about fifteen feet above water-level and about one hundred and fifty yards from the water's edge. The native village of Ooglaamie, containing about thirty "igloos" and one hundred and fifty inhabitants, is situated about half a mile distant to the southwest. Point Barrow is ten miles distant to the northeast. Cape Smyth is only a cape by courtesy, for there is scarcely a break in the coast-line, which runs uniformly in a northeast and southwest direction from Point Barrow to Wainwright Inlet.

The prospect from the station, even in summer, when it is at its best, is monotonous and uninviting, and in winter it must be dreary indeed. The tundra spreads away level and brown, relieved here and there by patches of sickly green, guttered in all directions by shallow water-courses, and covered with small shallow pools, while at no point within view does it reach an elevation of fifty feet above the level of the sea. Vegetation is very scanty, consisting chiefly of moss and lichens and other cryptogamous growths, with occasional patches of hard, wiry, grass and a few simple flowers. The only shrub to be found is the dwarf willow, which, instead of growing in an erect position, creeps along under the moss as if trying to hide from the inclement blasts, and in summer, it shoots forth its pretty rose-colored catkins and green leaves through its mossy covering in a timid and hesitating manner, as if aware of the uncongenial character of its surroundings.

During eight months of the year, the earth is frozen, and during the remaining four, it thaws to the depth of a foot from the surface, but below that depth it is permanently frozen to an unknown depth, probably one hundred and fifty to two hundred feet. It is a desolate land, interesting no doubt, but destitute of beauty, one in which the struggle for existence, both by animal and vegetable life, is of the hardest, where the aspects of nature are harsh without grandeur and desolate without being picturesque, and where the dead level of monotony everywhere prevails, the greatest variety being in the length of days and nights, which vary from seventy-two days to about as many minutes. The year is divided into seasons—a winter eight months long and a rather uncertain summer of four months. The latter season, if summer it can be called, is only such by contrast with the preceding winter, for the temperature rarely reaches 60°, and at any time a snow-storm may occur. Snow fell on every day we were at station. The lowest temperature experienced at station was 60° below zero. Luckily at such low temperatures the air is mostly still, and consequently people do not suffer so much as they do when the wind is blowing strongly, with the temperature considerably higher. Only two remarkable gales occurred, both in January—one continuing from the 11th to the 14th, and the other from the 21st to the 23d.

A description of the latter was given me. The wind reached a velocity of one hundred and four miles an hour, while for twenty-four hours the average velocity was over fifty miles. It is said the force of this gale was tremendous. Before its force the snow became impalpable powder and disappeared as if a sudden thaw had occurred. Sand and even coarse gravel were carried along in clouds and acted on exposed surfaces much the same as a sand-blast would. Wood and iron looked as if they had been subjected to a strong scouring process, and glass was ground so as to be almost opaque. One of the anemometers at station was broken long before the wind reached its highest velocity—the end of the spindle on which the cups

revolve being twisted off—but another stood the storm through without further damage than the blowing away of the wires which connect it with the self-register. The ice at sea, that previously seemed as immovable as the land, was broken up into fragments, as close in shore as half a mile, and when the storm abated was rushing away to the northeast with the velocity of a mill-race.

The sea at Point Barrow does not freeze to a greater depth than six or seven feet; the ice with which it is filled comes from a distance, and is generally a mixture of new and old worn ice. There is nothing in this sea approaching an iceberg, but still some very respectable masses are formed, especially near the coast, where the pressure of the moving floes from without is met by the resistance of the land, and huge fields of ice are driven over each other until they become grounded in water from fifteen to twenty fathoms deep and are piled up some forty or fifty feet. No doubt the grandeur and sublimity given to arctic scenery by the immensity of ice-bergs are here wanting, but the immensity of power displayed by the chaotic jumble of these enormous ice masses is more calculated to impress the mind than the mere bulk of lofty bergs that stud the seas on the eastern side of this continent. The broken floes are thrown together in every conceivable position, and at every possible inclination of surface, in a profusion of irregularity, of which no language can convey an adequate idea, and which must needs be seen to be appreciated.

Travelling over such a surface as this is next to impossible, and men without encumbrances could possibly advance eight or ten miles in a day, but if laden with food or otherwise, their progress would be far less than this—heavy ice-sleds would be almost impossible. Wherever there is land there is always an ice-foot—a narrow strip of level ice along the coast, over which sled-travel can be easily carried on, or in narrow channels without currents, when the ice may be comparatively smooth, but in the open sea, at a distance from land, such travel need never be attempted by any means now at our command, for nothing but failure will attend such attempts. The fringe of grounded ice along the Point-Barrow coast follows an irregular line, more or less distant from the shore, depending on the depth of the water, and varies from three to five miles in width.

Beyond the grounded line, the surface of the hummocks and floes is just as rough and uneven as it is anywhere else, but there is always more or less change going on—sometimes slowly and sometimes rapidly. Although to the eye the broad expanse of jumbled ice-hummocks seems as stable as the solid land, the stability is only apparent; a kind of vibratory motion takes place from time to time; the pressure increases and decreases alternately; currents set in, and the whole body of the ice seems to oscillate to and fro, so that it is seldom that the peculiar noises occasioned by the grinding and crushing together of the slowly moving masses cannot be heard. This song of the icy sea is a very peculiar one, and can scarcely be described so as to convey any clear idea of its nature. It is not loud, yet it can be heard to a great distance; it is neither a surge nor a swash, but a kind of slow, crashing, groaning, shrieking sound, in which sharp, silvery tinklings mingle with the low thunderous undertone of a rushing tempest. It impresses one with the idea of nearness and distance at the same time, and also that of immense forces in conflict. When this confused fantasia is heard from afar through the stilliness of this Arctic zone, the effect is strangely weird and solemn—as if it were the distant hum of an active, living, world breaking across the boundaries of silence, solitude, and death.

The sun set on the 16th of November and did not rise again until the 22d of January, remaining below the horizon for seventy-two days, but there was no day during this long, dreary, period that there was not two to three hours of twilight—twilight sufficient to hide the stars. On the 16th of May, the sun ceased to set, and from that day until the 29th of July there was continual day.

During the latter part of winter and early part of summer, the ice-drift at Point

Barrow is almost always from the southwest to the northeast, but about October it begins to move in an opposite direction, and continues in November and December drifting in the same way.

A description of auroral displays, furnished me by members of the party, would lead me to suppose that no known portion of the globe surpasses Point Barrow, and few equal it in the intensity and brilliancy of these displays. The brilliancy of the displays bears no proportion to their number. It was only occasionally that great splendor and magnificence were reached, and the duration of the greatest brilliancy was only brief, compared with that of the display of which it formed a part. Individual auroras often lasted ten or twelve hours, or more, but the great bursts of splendor and motion seldom lasted more than thirty minutes, and often did not continue even so long; but while they lasted they were magnificent, indeed. On such occasions the sky became a gorgeous canopy of flames, all splendor, color, and motion; arch, column, and banner flashed and faded; silvery rays, with rosy bases and fringed with gold or emerald green, danced and whirled around the zenith, and broad curtains of light flung across the sky in every form of graceful curve and convolution, shook rainbow tints from every fold, until the beholder became bewildered and lost in the dazzling brilliancy.

In lower latitudes, the aurora is mostly seen as a luminous arch extending across the northern sky. At Point Barrow, the arched form, though common, was not the prevalent one, and the arches that appeared were seldom perfect, or if so, only for a few moments at a time, and the changes of form were so incessant that it was hard to decide which was the prevailing type. The curtain form mostly broken, but always convoluted and folded on itself like an immense scroll, was a common form, but whatever the form, the phenomena passed over the sky in a succession of waves, sometimes from north to south and vice versa. Intimately connected with the aurora was the disturbance of the magnetic needles—in fact, during the prevalence of the aurora, the magnets were in a state of chronic perturbation, especially during the great displays, when they were often so disturbed that some of them could not be read.

Lieutenant Ray informed me that upon one occasion he saw what he considered to be land, apparently elevated by mirage, directly north of the station. It seemed quite extensive and appeared like the rounded hill-tops of a large island rising above the horizon. Because of the existence of the strong current moving to the northeast at Point Barrow, which runs like a mill-race, it would seem probable that land should exist to the north, and the current between these two lands should be considerably increased according to well-known scientific principles, or possibly, no current, save that created by winds, would be found along the Point-Barrow coast unless there was land to the north. If the problem of the pole is ever solved, I venture to assert that land will be found at or near it, extending as a continuation of Greenland.

Lieutenant Ray also informed me that while making a trip to the southward in March last he discovered a large river flowing in a northeasterly direction, and emptying itself into Dease inlet, about forty miles to the eastward of the station. This river he named the Meade river, after the late General Meade. It is over one hundred yards wide in some places, and is deep enough to allow plenty of large fish to live in it during winter.

The Esquimaux race, to which the natives of Point Barrow and other places on the American side at which the vessel stopped belong, have already been pretty fully described by Arctic explorers; but the description of the Point-Barrow Esquimaux, as given me by Lieutenant Ray and Sergeant Cassidy, is very valuable. Very little has been written about the natives. They are called Innuits, from the word "Innuit," which means man in their language, the plural of which is "Innuine," meaning men

or people. Although there is great general resemblance between all the subdivisions of the Esquimaux race; yet, there is considerable disparity existing between the various families, both in language and manners, depending, no doubt, on the accidental circumstances of locality, surroundings, etc.

The language of the eastern Esquimaux would be entirely unintelligible to the natives of the western coast; and even the native of our side of Behring strait speaks a dialect differing considerably from that of the Siberian side. There are, in fact, many more points of similarity between all the natives of the eastern side of Behring sea, than there are between them and the natives of the opposite side; thus the natives of the Diomedes islands, in the middle of Behring straits, differ more in language and dress from the natives of East Cape, Asia, only twenty miles away, than the natives of Point Barrow do from those of Norton sound, nearly seven hundred miles to the southward. The natives on the American side are, on the whole, superior to those on the Asiatic,—better looking, more intelligent and cleanly, where cleanliness of course only means a less degree of filthiness,—and the natives of Point Barrow are a trifle superior to any of the natives I saw at any other point on the American side.

It seems to be the universal law that the savage deteriorates when he comes in contact with civilization, and the longer the contact the more abject he becomes; no one passing along the coasts of Behring sea and of the Arctic ocean to Point Barrow can fail to be struck by the clear exemplification of this law. There seems to be a strong tendency in savage man everywhere to acquire the bad habits of the civilized rather than the good, whenever the two races come into contact, and the Esquimaux is no exception to this rule. Thus the natives of Point Barrow, having had but little intercourse with the white man, have deteriorated less than the tribes to the southward, and are quite respectable people for savages. They are rather a good-looking people, with interesting but not handsome faces. In general their noses are too flat and the complexions too coppery for beauty. Their bodies are well formed and of average stature; their hands and feet are smaller and better formed than those of the average white man, and, if they had laid aside one or two rather nasty habits and learned to wash themselves occasionally, they might be considered tolerably handsome. The women are more intelligent and better looking than the men, and are treated with more consideration than among most savages. Still the man is the lord and master, and his wife or his daughters have no rights he is bound to respect by any code of law or morals existing among them. A woman cannot choose her husband, but is given away much the same as a cow or horse, and her husband can beat her, or put her away, or sell her, at pleasure, except she may happen to have more friends than he has, and then it may not be altogether safe for him to exercise his lordly prerogatives too freely. Self-interest, however, and the indolent, easy-going habits of these people, prevent the existence of much harshness between man and wife. The females of a marriageable age are seldom in excess of the males, and consequently there is but little choice allowed, besides it is imperative that every man shall have a wife if possible, because an Innuit without one is about as forlorn and helpless an individual as can well be imagined. Without a woman to cook his food, mend his boots and clothing, and attend to various other matters, the performance of which is considered to be beneath the dignity of the masculine nature, the man soon becomes ragged and out at the elbows, unless some sisterly relative takes him under her care. There is no such thing as marriage ceremony. The whole affair is a bargain and of no more importance than any other bargain. No morality, in the proper sense of the term, exists, nothing intrinsically right or wrong. Individuals have rights if they are able to maintain them, so that really might is the great arbiter of right, except in such cases where superstition steps in and exerts a regulating influence over conduct.

Notwithstanding all this, the social relations are carried on as smoothly, and with as little injustice as among civilized people. There are leading men whose influence depends on their wealth and the number of their relatives and friends, but no chiefs, hereditary or otherwise, whose behests any one is bound to obey. There are shamans or medicine-men who talk to the spirits of good or evil and whose interference is required in almost every relation in life. Before a man goes hunting, fishing, or on a journey, when any mishap befalls him, sickness, ill-luck or adversity of any kind, the shaman is called upon to deal with the spirit, which means to howl in the most discordant way imaginable, with an accompaniment played on skin drums or tom-toms. This office of shaman belongs to no one in particular, as any one who can howl with the proper amount of discordance can fill it, but if any one turns out more fortunate than the rest in bringing good weather, in effecting cures, and in bringing success in hunting or fishing, he will be most in demand for the time being. Every one seems to believe in spirits and plenty of them; some of them evil and some good, which may be conciliated or driven away by the shaman. There seems to be no belief in any other state of existence than the earthly one, and death is the end of all things to each and every one; when a man dies that is the end. It would seem that the poor savage treats life more philosophically than we do. To him there is neither reward nor punishment in the hereafter, and when the end approaches he passes away from this world as peacefully as an infant, with none of the terrors which possess many civilized persons when brought face to face with death.

Still, some trace in a belief of a future state that formerly did exist, and probably in some dim way exists still, is to be found in the habit of sometimes burying with the dead his bow and arrows, his knife, pipe, and other articles which he used while living, but curiously enough, nearly all of them are previously broken, and thus it might be considered as a mournful observance rather than an evidence of spiritual belief. Burial, of course, with the Innuit means simply exposure. The dead body is rolled up in a deer-skin or walrus hide and laid between the runners of a broken sled on some convenient knoll, where the winter winds and summer suns, aided by the wild foxes of the tundra, soon accomplish the work of disintegration.

The social habits of these people, although no worse than the rest of their race, are very repugnant to an ordinary civilized man. Squalor and filth are everywhere; dirt prevails in their food, in their living, and in all their personal surroundings. Indeed, some of their habits are unmentionably repulsive; and, I believe, there are no words in their language corresponding to our words dirt and cleanliness. I will, however, do them justice to say that they are entirely unconscious of their condition, and that they are simply dirty by the prescriptive right of ages of antecedent conditions, moving always in the conservative grooves of savage life. It seems that, if a savage man makes any progress toward civilization, cleanliness is about the last line in which he makes any advance.

As is well known, the food of the Innuit consists, mainly, of the flesh of the seal, the walrus, and the reindeer, with occasional variations of birds and fish. The mode of cooking is by boiling, which is done over a wood fire, in open air, during summer, and over their oil lamps in winter. The blood and intestines of bird and beast are carefully preserved and boiled with the rest of the animal, and any one who has seen the process in operation, must needs feel the stings of hunger pretty sharply before he can bring himself to partake of the resulting dish. The seal and the reindeer furnish by far the greater portion of their food, and should the supply of either of these animals fail, but more especially the former, starvation would ensue. Seals are caught during the winter in large numbers through their breathing-holes in the ice, either by spearing or netting. The reindeer are killed during the months of March, April, October, and November. During the winter months, food is often

very scarce, and many families have to depend for weeks on the little polar-cod, a fish about six inches long. No doubt since the advent of civilized man, there has been considerable change in the Innuit modes of living and obtaining food. The arrow and the sling, though still in use, have given place to the rifle and the shot-gun; flint and ivory have been somewhat superseded by iron and lead, and their summer tents are now seldom made of anything but canvas, while cooking is done in iron pots and kettles instead of in the stone basins formerly in use.

Having turned over all supplies to Lieutenant Ray, Sunday, August 27th, and relieved from duty under my charge Sergeant Joseph E. Maxfield and Privates Charles Ancor and John A. Guzman, and receiving all mail destined for the United States, preparations were made to leave this dreary region—a region which seems to me to be one in which the bright sunshine of hope enters with a light so subdued that it is but the gleam from a far distant planet penetrating the cavern of ceaseless solitude and woe.

By reason of the severity of the climate, Sergeant James Cassidy was relieved by Lieutenant Ray from duty at Ooglaamie, and returned with me to San Francisco.

Anchor was weighed at 2 p. m. Sunday, and our homeward voyage begun in a snow-storm. Heavy drift-ice was moving rapidly to the southwest. This ice was of very peculiar construction and of varied tints, with height from three to thirty feet. Before the gale began, which was previously mentioned as occurring on the 24th, the ice began drifting from the northeast, in a contrary direction to its usual course, and I judged from the movement on Sunday, being identically the same, we would have another gale from the same quarter. My judgment was correct; for, on Monday, the gale commenced in earnest. We passed Point Belcher at 9 a. m., August 28th, and Icy Cape at 11 p. m.

During the day the temperature of the water changed in one hour from 36° to 31.5°, showing that there existed a warm current, which we crossed. We passed Cape Lisburne at 12 m., August 29th.

By the terms of the contract, the owner of the vessel was allowed to engage in any private enterprises he saw fit, after delivering supplies at Ooglaamie. Consequently, when we left station, I turned the vessel over to the master and ceased to direct its movements, but stipulated that we would return to Plover bay in order to obtain more observations.

We reached East Cape, Asia, Saturday, September 20th, and laid there Sunday and Monday. There is quite a large village located at East Cape, and the natives have a regularly installed chief—the only place we visited where we found a chief. We sailed from East Cape to the Diomedes islands, reaching there at 8 a. m. in a gale from the east. Left the Diomedes at 12 midnight, bound for Saint Lawrence bay, and anchored inside the harbor at 3 p. m. next day. This bay is full of historic reminiscences connected with the burning of the United States steamer "Rodgers," of the Jeannette Relief Expedition. The natives came on board clothed in some of the apparel left them by the officers and crew of this ill-fated vessel. Several had recommendations from the Rodger's party, and in compliance with requests made therein, each one was supplied with tobacco, bread, and molasses. One of the natives described to me the accident which befell Master Putnam of the navy, and stated that some time after the ice-floe, bearing Putnam, drifted out to sea, a south-easterly wind brought the floe back to shore, and he saw the remains of Putnam on it, his face and hands much discolored and the body swollen. The ice did not remain long, but floated out again, moving toward the Arctic.

We left Saint Lawrence bay on September 8th, and reached Plover bay on the 11th, at 2 p. m. Owing to cloudiness, I failed to get an observation of the sun on that day. On Tuesday the 9th, I left the vessel for shore at 7.30 a. m., but had to wait an hour for the fog to rise. Succeeded in getting two sights, but had to

suspend operations, as rain began to fall. It cleared up sufficiently by the afternoon to secure six sights through the clouds—three upper and three lower limb.

We sailed from Plover bay September 13th for Fort Saint Michael's, to return the native, Kan-u-ark, who shipped with us at that place. Shortly after leaving Plover bay a gale sprang up, which compelled us to alter our course and run to the south of Saint Lawrence island. At 5 p. m. of the 14th, the ship struck a reef of hidden rocks, not marked on chart, about six miles south of the island. For a while it looked as if we would winter in this region, or else go to the bottom. The heavy sea favored the vessel in getting off. The pumps were manned, and, to our satisfaction, we found but little water was making. Made Saint Michael's September 17th. While at this place I made informal inspection of the signal office. Left Saint Michael's on the 20th, and touched at Golovin bay same date. On the 28th of September, in Behring sea, the barometer commenced falling rapidly, and a fierce gale sprang up from the east, which soon blew with so much violence that we were obliged to take in all our canvas and heave to under a double reefed main-sail and foresail. We expected by the next day that it would have blown itself out and the worst be over, but it only increased in fury, and for the next day, and the next, and for full five, we were tossed to and fro, at the mercy of such a storm as I hope I shall never again experience. By the time the storm was over, the entire party were worn out, and the patience exhibited under such circumstances certainly became a virtue. We passed through Unimak pass on the 5th of October. Our voyage from thence across the Pacific to San Francisco was, on the whole, favorable, and we reached the latter place October 2d. It was three days before the vessel could be docked, and mail and freight forwarded to Washington.

I turned over to the United States Coast and Geodetic Survey, the chronometers for the purpose of rating. As the rates of the several chronometers have been determined, it would appear, from a careful examination of the record, that I was justified in using number 1683 (the standard) at Point Barrow without correction for rate, as the rate changed from losing to gaining during the voyage.

I regret that I am so pressed for time that I cannot embrace in this report any results deduced from the meteorological observations made during the voyage. Hourly meteorological observations were made without a single interruption. In this connection I desire to refer, with pleasure, to the great assistance given me by Sergeant James Cassidy and Private Frederic H. Clarke. These two men, on the return voyage, took all meteorological observations. These had to be made at all times, and the bravery shown by Sergeant Cassidy and Private Clarke in venturing on the deck of the vessel during storms, when heavy seas were pouring over her, is praisworthy, and I earnestly commend them to the favorable consideration of the Chief Signal Officer.

Strong currents were found in Behring sea and in the Arctic. At some near date I hope to be able to make an additional report relating to these, and also submit certain theories relative to the movements of areas of low barometer across Behring sea. I am of the opinion that the theory of the ocean being the birthplace of storms is erroneous. But these matters will be investigated as soon as an opportunity presents itself.

Very respectfully, your obedient servant,

JOSEPH S. POWELL,

2d Lieutenant, Signal Corps, U. S. Army, Assistant.

APPENDIX.

Report of Mr. Winslow Upton, Computer Office of the Chief Signal Officer, on the longitude of the United States Polar Station at Ooglaamie, Alaska, from chronometer comparisons and observations made by the Expedition under Lieutenant Joseph S. Powell.

I. General Description of the Expedition.

The Point Barrow supply expedition which visited the polar station in the summer of 1882, under the command of Lieutenant Powell, was instructed to determine the longitude of the station by means of chronometers. For this purpose the following chronometers were employed:—

Negus 1683, mean time.
Negus 1691, mean time.
Negus 1692, sidereal time.
Negus 1693, sidereal time.

Lieutenant Powell in his report (6805, Mis., 1882, App. A) states that these chronometers "were placed, still enclosed in the boxes in which they were sent from the manufacturers, in the state-room farthest removed from the companion-way and nearest the middle of the vessel. They were firmly secured to shelves." In addition, the ship chronometer, Harpur 396, was available for the daily comparisons.

The following was the plan of the expedition:—

1. Determination of the chronometer corrections and rates by the United States Coast and Geodetic Survey at San Francisco.

2. Daily comparisons of the chronometers during the voyage.

3. Determination of the chronometer corrections and sea rates from San Francisco at Plover bay, whose position is well determined.

4. Determination of the chronometer corrections at Point Barrow, and comparison with the local time as determined by Lieutenant Kay, in charge of the station.

5. Repetition of the observations at Plover bay on the return voyage, and at San Francisco after the return.

This programme was carried out faithfully, but, unfortunately, cloudy weather interfered seriously with the proposed observations. At Plover bay, but two settings with the sextant were obtained on the voyage to Point Barrow, and but eight on the return voyage, while at Point Barrow but three time determinations with the sextant were made, the first being incomplete. Lieutenant Kay had made but one time determination for six weeks preceding the arrival of the party, and therefore his chronometric corrections were unreliable. The daily chronometer comparisons were made without any omission, and the observations at San Francisco before and after the voyage were successful. On account of the partial failure of the observations, as above, it is impossible to obtain as good results as was hoped.

They have all been carefully reduced, and the following condensed account is given of the methods employed and results obtained:—

II. Observations before and after the voyage.

A copy of the observations and chronometer comparisons made at San Francisco has been furnished by the Superintendent of the United States Coast and Geodetic Survey. The observations were made at the Lafayette Park observatory, by

Messrs. Ferdinand Westdahl and Chas. B. Hill, with a Troughton & Simms Transit (U. S. C. S., No. 3.)

The position of the instrument is:—

Latitude 37° 47′ 22.56″ N.
Longitude 122° 25′ 41.23″ W. } of Greenwich.
or, 8 h. 9 m. 42.75 s. W. }

The observations before the voyage were made June 19, 20, and 21. These were reduced by the method of least squares, and the following corrections and rates furnished Lieutenant Powell by the observer:—

June 21, San Francisco mean time, ten hours.
M. T. Negus 1683, 6 h. 2 m. 38.1 s., fast of San Francisco mean time,
or, 2 h. 7 m. 4.6 s., slow of Greenwich mean time.
Approximate rate 0.6 s., losing daily.

M. T. Negus 1691, 2 h. 50 m. 59.5 s., fast of San Francisco mean time.
S. T. Negus 1692, 4 h. 26 m. 32.9 s., fast of San Francisco sidereal time.
S. T. Negus 1693, 4 h. 34 m. 43.7 s., fast of San Francisco sidereal time.

The observer's note states, "These were hastily computed from coincidences taken on the morning of June 21st, and without allowing for the rate of mean time, 4969, the 'Hack.'"

An examination of the observations showed that the separate results were somewhat discordant, but that the values given were probably reliable to a fraction of a second. The rate given for 1683 was evidently unreliable, as it was determined from observations not sufficiently accordant to give the rates for short intervals of time. It was thought unnecessary to make a new reduction of the observations, as the above is sufficiently accurate for the purpose of this computation.

After the return of the vessel, observations were made on October 27th and 28th, with the following results:—

M. T., Negus 1683, 6 h. 3 m. 2.5 s., fast of San Francisco mean time.
M. T., Negus 1691, 2 h. 53 m. 4.8 s., fast of San Francisco mean time.
S. T., Negus 1692, 4 h. 27 m. 47.8 s., fast of San Francisco sidereal time.
S. T., Negus 1693, 4 h. 33 m. 55.1 s., fast of San Francisco sidereal time.

The average daily rates of the chronometers from June 31st, to October 28th, 1882, are, therefore:—

M. T., 1683, gaining 0.1891 s.
M. T., 1691, gaining 0.9713 s.
S. T., 1692, gaining 0.5806 s.
S. T., 1693, losing 0.3767 s.

The rate for 1692 was modified during the computation as will be explained later.

III. Observations at Plover Bay.

On the voyage to Point Barrow, a stop was made at Plover bay for the purpose of determining the local time.

On account of clouds, the following only were obtained:—

August 6, p. m.

Observed 2 *alt.*	*Chron.* 1692.
Sun's upper limb, 64° 18′ 00″	8 h. 7 m. 52.5 s.
Sun's upper limb, 64° 32′ 10″	8 h. 12 m. 21.5 s.

Index corrections, zero.

Reducing these readings separately, the following corrections were obtained, the position of Plover bay being regarded as lat. 64° 22′ 0″, long. 11 h. 33 m. 26 s. (V, Bulletin of the Philosophical Society of Washington, vol. iv., p. 130.)

Chron. 1692, —4 h. 25 m. 57.4 s., on San Francisco sidereal time.
Chron. 1692, —4 h. 25 m. 58.4 s., on San Francisco sidereal time.
Mean, —4 h. 25 m. 57.9 s., on San Francisco sidereal time.

Combining this value with the chronometer comparisons made before and after the observations, we have the following corrections :—

M. T., 1683, —6 h. 2 m. 33.7 s., on San Francisco mean time.
M. T., 1691, —2 h. 51 m. 11.2 s., on San Francisco mean time.
S. T., 1692, —4 h. 25 m. 57.9 s., on San Francisco sidereal time.
S. T., 1693, —4 h. 33 m. 27.0 s., on San Francisco sidereal time.
M. T., 396, —7 h. 52 m. 7.9 s., on San Francisco mean time.
M. T., 887, —9 h. 11 m. 20.2 s., slow of Greenwich mean time.

Chronometer, M. T., 887, is the chronometer of the United States Steamer Corwin, which was at Plover bay on that day, its error was said to be 11 m. 20.4 s. slow of Greenwich mean time, which chances to be in almost absolute agreement with the result given.

On the return voyage, the following observations were made :—

September 12, a. m.

Observed 2 *alt.*	*Chron.* 1692.
Sun's upper limb, 39° 19′ 30″	3 h. 52 m. 37.5 s.
Sun's upper limb, 39° 27′ 30″	3 h. 53 m. 27.5 s.

Index error + 4′ 30″.

Barometer, 29.75 ; thermometer, 40°.

September 12, p. m.

Observed 2 *alt.*	*Chron.* 1692.
Sun's upper limb, 27° 43′ 0″.	11 h. 33 m. 38.5 s.
Sun's upper limb, 27° 34′ 0″.	11 h. 34 m. 18.5 s.
Sun's upper limb, 27° 28′ 0″.	11 h. 34 m. 48 s.
Sun's lower limb, 27° 19′ 0″.	11 h. 36 m. 3 s.
Sun's lower limb, 27° 12′ 0″.	11 h. 36 m. 39.5 s.
Sun's lower limb, 26° 59′ 0″.	11 h, 37 m. 38.5 s.

Index error, + 4′ 30″.

Barometer, 29.71 ; thermometer, 40°.

Lieutenant Powell's notes for the a. m. observation: "The above observations were taken under difficulties. The weather was partly cloudy, and raining slightly. They are, therefore, not considered good."

At the p. m. observation he says: "The same trouble in regard to clouds existed during the afternoon observations. The results are not considered good, but sufficient to act as checks."

In reducing these observations, it was assumed that "index error" should be "index correction," as the observer had so regarded it in his reductions, and as the original observations by which it was obtained are not recorded in the observer's note-book. It was also necessary to regard the observed altitudes in the last set of observations as 28°, instead of 27°, as recorded.

The following were the results obtained for the correction to 1692:

4 h. 25 m. 32.7 s. a. m., first reading.
4 h. 25 m. 36.5 s. a. m., second reading.
4 h. 25 m. 37.6 s. p. m., first group.
4 h. 26 m. 7.4 s. p. m., second group.

Giving the first and second observations half weight, as they depend upon single readings only, we have :—

4 h. 25 m. 53.2 s.

Combining this with the chronometer comparisons made before and after the observations, the following corrections result:—

M. T, 1683, —6 h. 2 m. 27.6 s., on San Francisco mean time.
M. T. 1691, —2 h. 51 m. 42.9 s., on San Francisco mean time.
S. T. 1692, —4 h. 25 m. 53.2 s., on San Francisco sidereal time.
S. T. 1693, —4 h. 33 m. 9.1 s., on San Francisco sidereal time.
M. T. 396, —7 h. 50 m. 31.3 s., on San Francisco mean time.

IV. Observations at Point Barrow.

The observations at Point Barrow were made at the observatory of the station at Ooglaamie on August 22d, a. m. and p. m., and August 26th, p. m.

They are given below with the reductions of each:—

August 22, a. m.

Observed 2 alt.		*Time by* 1713.
D	51° 50′	7 h. 24 m. 15 s.
Sun's lower limb,	51 55	7 h. 25 m. 4 s.
	52 00	7 h. 25 m. 49 s.
R	51 50	7 h. 34 m. 0.5 s.
Sun's upper limb,	51 55	7 h. 34 m. 42.5 s.
	52 00	7 h. 35 m. 28 s.

MAXFIELD, *Observer.*

D	53° 25′	7 h. 49 m. 58 s.
Sun's lower limb,	53 30	7 h. 50 m. 45.1 s.
	53 35	7 h. 51 m. 19.5 s.
	53 40	7 h. 52 m. 17.5 s.
	53 45	7 h. 53 m. 9.5 s.

Index error, —1′ 0″. DARKE, *Observer.*

"Had great difficulty in getting contacts on account of variability in the refraction."

The observations were unsatistactory and the reductions quite discordant. It was assumed that "index error" should be "index correction," as the observer had so regarded it, and as the record of August 26 has the word "correction." The reduction of the observations made by Mr. Darke differed ten minutes from those made by Sergeant Maxfield, the latter agreeing with those made in the afternoon. Assuming that the observed double altitude should be 54° instead of 53°, this discrepancy was removed and the resulting corrections of chronometer 1713 are:—

+ 1 h. 58 m. 53.6 s., on local mean time.
+ 1 h. 58 m. 15.7 s.

August 22, p. m.

Cover direct.—Observed 2 alt.		*Chron.* 1713.
	47° 40′	1 h. 7 m. 18 s.
	47 35	1 h. 8 m. 5.5 s.
	47 30	1 h. 8 m. 43.5 s., clear.
Sun's upper limb,	47 25	1 h. 9 m. 28.5 s.
	47 20	1 h. 10 m. 6.5 s.
	47 15	1 h. 10 m. 47.5 s.
Cover reverse.		
	47 40	1 h. 15 m. 43.5 s.
	47 35	1 h. 16 m. 27 s.
	47 30	1 h. 17 m. 4.5 s., partly cloudy.
Sun's lower limb,	47 25	1 h. 17 m. 48.5 s.
	47 20	1 h. 18 m. 27 s.
	47 15	missed.

Index error, —1′ 0″. MAXFIELD, *Observer.*

The reduction of these observations gives for the correction of chronometer 1713, on local time:—

+ 1 h. 59 m. 39.8 s.
1 h. 59 m. 24.7 s.
Mean, 1 h. 59 m. 32.2 s.

August 26, p. m.

Observed 2 *alt.*			*Chron.* 1713.	
Sun's lower limb,	48°	36′ 40″	12 h. 44 m. 48 s.	cloudy.
	48	28 20	12 h. 46 m. 14.5 s.	
	48	16 30	12 h. 47 m. 57 s.	contact poor.
	48	11 00	12 h. 48 m. 37 s.	
	48	3 50	12 h. 49 m. 40.5 s.	
	47	57 20	12 h. 50 m. 39.5 s.	
Sun's upper limb,	46	31 40	12 h. 53 m. 43 s.	
	46	26 40	12 h. 54 m. 24 s.	
	46	21 00	12 h. 55 m. 11.5 s.	contact better.
	46	15 10	12 h. 55 m. 53.5 s.	
	46	7 50	12 h. 57 m. 3 s.	
	46	3 10	12 h. 57 m. 41.5 s.	

Index correction, —1′ 0″.

Weather cloudy. Further observations stopped by clouds.

MAXFIELD, *Observer.*

The reduction of these observations gives the following corrections to chronometer 1713:—

+ 1 h. 59 m. 35.0 s.
1 h. 59 m. 43.2 s.
Mean 1 h. 59 m. 39.1 s.

Tabulating the results given above, we have for the corrections to chronometer 1713:—

August 22, a. m., + 1 h. 58 m. 53.6 s. } Very uncertain.
1 h. 58 m. 15.7 s. }
" 22, p. m., 1 h. 59 m. 32.2 s.
" 26, p. m., 1 h. 59 m. 39.1 s.
Daily rate 1.73 s., losing.

Observations made in this latitude, with the sextant under the best conditions, are subject to an uncertainty of several seconds.

A preliminary computation of the longitude made by using the observations of August 22d, p. m., and August 26th, p. m., with the rate given by them, showed for the daily comparisons a series of progressive values corresponding to the assumed rate. It was therefore evident that no reliance could be placed on the rate 1.73 s., given above.

Rejecting the morning observations of August 22d, and taking the mean of the others, we have for the chronometer correction of 1713:—

August 24, + 1 h. 59 m. 35.6 s.

Chronometer 1713 was one of those belonging to Lieutenant Ray in charge of the station at Ooglaamie. He furnished the following as its correction and rate:—

August 25, + 1 h. 59 m. 27.5 s., losing 0.1 s.

The records which were brought back from Lieutenant Ray do not show exactly how this value was obtained, but it apparently depends upon an observation made on August 16th with the sextant,

V. Computation of the Longitude.

From the data furnished by the observations we proceed now to determine the longitude of Ooglaamie by several methods:—

(1.) By using the mean sea rates for each chronometer.

In section ii. are given the mean sea rates of the four chronometers, negus Nos. 1683, 1691, 1692, 1693, determined from the observations at San Francisco before and after the voyage.

The daily comparisons showed that the deviations from the mean rates were progressive, and characterized by no sudden changes, except in one instance. On September 14th, the ship was violently jarred by striking a rock. None of the chronometers seem to have been affected except No. 1692, which from that date, had a rate differing from its former rate by about 1.2 s.

Assuming that this change occurred at about the time of the comparisons on September 15th, we can determine its mean rate as follows:—

1692, correction.

June 21st, 10 a. m., 4 h. 26 m. 32.9 s.

Oct. 28th, 10 a. m., 4 h. 27 m. 47.8 s.

Difference, 74.9 s.

$$86\,r + 43\,(r + 1.2) = 74.9 \text{ s.}$$

$$r = 0.1806 \text{ s., gaining.}$$

$$r + 1.2 = 1.3806, \text{ s., gaining.}$$

The former value is to be used from June 21st to September 15th; the latter from September 15th to October 28th.

The ship's chronometer, Harpur 396, was not compared with the others at San Francisco, but was included in the daily comparisons throughout the voyage; its rate can therefore be determined by using the mean rate of any of the other chronometers for a few days only at each end of the voyage. Using 1683 for this purpose, we have for the corrections and rate of 396 the following values:

June 24th, —7 h. 53 m. 37.0 s.

Oct. 24th, —7 h. 50 m. 2.4 s,

Difference, 3 m. 34.6 s.

Daily rate, 1.7596 s., losing.

At Point Barrow, comparisons were made of the chronometers with those of Lieutenant Ray, on August 22d, 23d, 24th and 27th.

We have adopted in section iv, a correction for chronometer 1713, which is applicable to August 24th. A trial showed that the same result, within a few tenths of a second, was obtained by using August 24th alone, and by using all the comparisons, adopting the same correction for 1713, with no rate.

It is therefore sufficient to use the comparisons of August 24th as the reference point for the Point Barrow observations. The following table gives the chronometer corrections computed from the mean sea rates given above; and the resulting longitude expressed in time west of Greenwich:

August 24, 1882.

Chronometer.	*Correction.*	*Longitude.*
1683	— 6 h. 2 m. 50.2 s.	10 h. 26 m. 32.9 s.
1691	— 2 h. 52 m. 1.8 s.	10 h. 26 m. 10.5 s.
396	— 7 h. 51 m. 47.5 s.	10 h. 26 m. 27.0 s.
1692	— 4 h. 26 m. 42.4 s.	10 h. 26 m. 3.7 s.
1693	— 4 h. 34 m. 19.5 s.	10 h. 25 m. 49.6 s.
	Mean	10 h. 26 m. 12.9 s.

(2.) By using the mean sea rates corrected for deviations of rate shown by the daily comparison.

No temperature observations were made during the voyage. In the cabin abjoining the state-room, a fire was kept burning, and probably the chronometers were not exposed to a very great range of temperature. But the daily comparisons show large deviations from the mean rates.

In order to examine these, the following table was prepared, which contains the observed relative rates of No. 1683 compared with each of the other chronometers in turn, and the deviations of the observed values from the mean relative rates. They are given for the mean of the five-day intervals contained in the column of dates.

Table showing the observed relative rates of the chronometers for five-day intervals, and the deviations from the mean relative rates:

1882.	1683. Relative rate.	1691. Deviation.	1683. Relative rate.	396. Deviation.	1683. Relative rate.	1692. Deviation.	1683. Relative rate.	1693. Deviation.
June 25–29	— .28 s.	— .50 s.	+1.02 s.	+ .93 s.	+ .52 s.	+ .51 s.	+1.56 s.	— .99 s.
30 to July 4	— .56	— .22	+1.50	+ .45	+ .74	— .73	+1.26	— .69
July 5–9	— .24	— .54	+1.68	+ .27	+ .86	— .85	+1.76	—1.19
10–14	+ .02	— .80	+2.06	— .11	+1.38	—1.37	+2.36	—1.79
15–19	— .28	— .50	+2.14	— .19	+ .76	— .75	+1.72	—1.15
20–24	— .62	— .16	+2.20	— .25	+ .60	— .59	+1.96	—1.39
25–29	— .66	— .12	+2.38	— .43	+ .72	— .71	+2.04	—1.47
30 to Aug. 3	— .08	— .70	+2.50	— .55	+ .60	— .59	+1.40	— .83
Aug. 4–8	— .32	— .46	+2.24	— .29	+ .12	— .11	+ .34	+ .23
9–13	— .38	— .40	+2.24	— .29	— .02	+ .03	+ .38	+ .19
14–18	— .50	— .28	+2.12	— .17	— .02	+ .03	+ .42	+ .15
19–23	—1.08	+ .30	+2.64	— .69	+ .06	— .05	+ .46	+ .11
24–28	—1.10	+ .32	+2.60	— .65	+ .24	— .23	+ .46	+ .11
29 to Sept. 2	—1.30	+ .52	+2.70	— .75	— .02	+ .03	+ .38	+ .19
Sept. 3–7	—1.38	+ .60	+2.04	— .69	— .10	+ .11	+ .22	+ .35
8–12	—1.54	+ .76	+2.24	— .29	— .50	+ .51	— .04	+ .61
13–17	—1.62	+ .84	+2.04	— .09	— .64	+ .17	— .18	+ .75
18–22	—1.36	+ .58	+2.38	— .43	—2.02	+ .83	— .22	+ .79
23–27	—1.36	+ .58	+1.64	+ .31	—1.76	+ .57	— .28	+ .85
28 to Oct. 2	—1.42	+ .64	+ .94	+1.01	—2.10	+ .91	— .44	+1.01
Oct. 3–7	— .98	+ .20	+1.50	+ .45	—1.94	+ .75	— .34	+ .91
8–12	— .94	+ .16	+1.16	+ .79	—2.02	+ .83	— .34	+ .91
13–17	— .82	+ .04	+1.10	+ .85	—1.94	+ .75	— .28	+ .85
18–22	— .72	— .06	+1.26	+ .69	—1.76	+ .57	— .22	+ .79
23–24	— .65	— .13	+1.70	+ .25	—1.60	+ .41	— .35	+ .92
Mean relative rate	—.78.		+1.95.		+.01 to Sept. 15th. —1 19 after Sept. 15th.			+.57.

It is evident, from this table, that the deviations from the mean rates are important, and that in general they follow the law of sines.

In the absence of any temperature observations, the best method of treating the deviations is to express them as a function of the time. There seems no reason for supposing that any one chronometer was poorer than the others; consequently we may select any one we please as a standard, and determine a series of corrections to its rate from the comparisons with the other chronometers. We have adopted 1683 as a standard, and have assumed that in the comparison with each, half of the respective deviations were chargeable to 1683 and half to the other chronometers. The mean of the four series of values thus obtained, with the opposite sign, gives the adopted corrections to the rate of 1683. They are as follows:

June 27	+ .14 s.	Aug. 6	+ .08 s.	Sept. 15	— .21 s.
July 2	.15 s.	" 11	.06 s.	" 20	.22 s.
" 7	.29 s.	" 16	.04 s.	" 25	.29 s.
" 12	.51 s.	" 21	.04 s.	" 30	.44 s.
" 17	.32 s.	" 26	— .06 s.	Oct. 5	.29 s.
" 22	.30 s.	" 31	.00 s.	" 10	.34 s.
" 27	.34 s.	Sept. 5	— .04 s.	" 15	.31 s.
Aug. 1	+ .34 s.	" 10	— .20 s.	" 20	— .25 s.

If we now regard the period of one hundred and twenty days, from June 25th to

October 23d, as a circumference, we can express these corrections in terms of the sines of the intervals from June 25th, by the formula $a \sin \gamma =$ correction.

Our expression for the rate of 1683 then becomes:—

$$r = + 0.1891 \text{ s.} + a \sin \gamma.$$

By solution:—

$$r = + 0.1891 \text{ s.} + 0.41 \sin \gamma.$$

The value of the term $0.41 \sin \gamma$ summed for the period, June 21st to August 24th, is 15.8 s., which may, therefore, be applied with the opposite sign as a correction to the longitude deduced from 1683 with a mean rate. The resulting longitude is:—

10 h. 26 m. 17.1 s.

A complete discussion of all the chronometers would necessitate the determination of similar corrections to the others. But it should be noted that if we determine the correction to 1683 as above, by reference to all the chronometers, and then by subtracting the adopted corrections of the standard chronometer from the observed deviations, determine corrections to the other chronometers in turn, we simply reduce all the chronometers to the standard with its assumed corrections. The results from the separate chronometers will then necessarily be brought into close agreement with each other, the only difference possible being due to the effect of smoothing the residuals by the sine formula. The agreement obtained is fictitious, since all the readings are by the process adopted, brought into harmony with those of the standard chronometer, whose correction has been assumed. The result of reducing all the chronometers amounts simply to a check upon the numerical computation. In the case of the chronometers used on this expedition, a numerical check was obtained by summing the residuals for each chronometer, without applying the sine formula.

The above result, 10 h. 26 m. 17.1 s., may then be regarded as the final value of the longitude obtained from the mean sea rate, corrected for the observed deviations during the voyage.

(3.) By using the mean sea rate obtained from the two observations at Plover bay.

In section iii. are given the chronometer corrections deduced from the observations at Plover bay on August 6th and September 12th.

The following table contains the resulting daily rates, the chronometer corrections on August 24th, and the deduced longitudes:—

Daily rate.	*Cor., Aug. 24.*	*Longitude.*
M. T. 1683, — .165 s.	6 h. 2 m. 30.7 s.	10 h. 26 m. 52.4 s.
M. T. 1691, + .857 s.	2 h. 51 m. 26.6 s.	10 h. 26 m. 45.7 s.
M. T. 396, —2.611 s.	7 h. 51 m. 20.9 s.	10 h. 26 m. 54.5 s.
S. T. 1692, — .127 s.	4 h. 25 m. 55.6 s.	10 h. 26 m. 50.5 s.
S. T. 2693, — .484 s.	4 h, 33 m. 18.3 s.	10 h. 26 m. 50.8 s.
		Mean, 10 h. 26 m. 50.8 s.

If we treat the observed relative rates given in the table on page 31 for the period, August 6 to September 12, and deduce the deviations from the mean, as was done in the case of the mean sea rates for the whole voyage above described, we have the following corrections to 1683:—

August 6, —.06 s.	August 26, —.05 s.
" 11, —.05 s.	" 31, .00 s.
" 16, —.06 s.	Sept. 5, +.11 s.
" 21, —.04 s.	" 10, +.13 s.

These do not follow any law of sines, but indicate that from August 6 to August 24, a correction of +.05 per day should be applied to the mean rate of 1683. The resulting longitude becomes 10 h. 26 m. 51.5 s., which closely agrees with the above value determined trom the uncorrected mean rates.

(4.) By using sea rates determined from San Francisco to Plover bay, or from Plover bay to San Francisco, this method gives the following rates, chronometer corrections, and longitudes:—

(*a.*) Sea rate from San Francisco to Plover bay.

Daily rate.	*Cor., Aug. 24.*	*Longitude.*
M. T. 1683, — .096 s.	6 h. 2 m. 32.0 s.	10 h. 26 m. 51.1 s.
M. T. 1691, + .254 s.	6 h. 51 m. 15.8 s.	10 h. 26 m. 56.5 s.
M. T. 396, —2.060 s.	7 h. 51 m. 30.8 s.	10 h. 26 m. 44.6 s.
S. T. 1692, — .761 s.	4 h. 25 m. 44.2 s.	10 h. 27 m. 1.9 s.
S. T. 1693, —1.667 s.	4 h. 32 m. 56.9 s.	10 h. 27 m. 12.2 s.
		Mean, 10 h. 26 m. 57.3 s.

(*b.*) Sea rate from Plover bay to San Francisco.

Daily rate.	*Cor., Aug. 24.*	*Longitude.*
M. T. 1683, + .759 s.	6 h. 2 m. 13.2 s.	10 h. 27 m. 9.9 s.
M. T. 1691, +1.780 s.	2 h. 51 m. 9.1 s.	10 h. 27 m. 3.2 s.
M. T. 396, — .743 s.	7 h. 50 m. 45.4 s.	10 h. 27 m. 30.0 s.
S. T. 1692, +1.370 s., before Sept. 15. +2.570 s., after Sept. 15.	4 h. 25 m. 27.2 s.	10 h. 27 m. 18.9 s.
S. T. 1693, +1.000 s.	4 h. 32 m. 50.1 s.	20 h. 27 m. 19.0 s.
		Mean, 10 h. 27 m. 16.2 s.

VI. Final Results.

The values given in the preceding section may be grouped as follows, the results being taken to the nearest second only:—

10 h. 26 m. 13 s. from mean rates for whole voyage, uncorrected.
10 h. 26 m. 17 s. from mean rates for whole voyage, corrected.
10 h. 26 m. 51 s. from mean rates from Plover bay to Plover bay, uncorrected.
10 h. 26 m. 52 s. from mean rates from Plover bay to Plover bay, corrected.
10 h. 26 m. 57 s. from mean rates from San Francisco to Plover bay.
10 h. 27 m. 16 s. from mean rates from Plover bay to San Francisco.

In all these, the local time at Point Barrow has been adopted as given by the observations made there with the sextant. The chronometer corrections furnished by Lieutenant Ray would give values 9.2 s. greater than the above.

In deciding what should be done with these results, it is necessary to regard the accuracy of the methods by which they were obtained, as these are by no means equal. The two last results are the least reliable, as rates determined in the one case from San Francisco to Plover Bay cannot be fairly used for the remainder of the voyage to Point Barrow; nor can it be assumed in the other case that the rate on the return voyage, as determined from Plover bay to San Francisco, can be carried back to Point Barrow. The discordance between the rates thus obtained, as compared with each other and with the rates at the part of the voyage from Plover bay to Plover bay, shows that the rates were too changeable to give this method any reliability.

The result obtained by determining the mean rates from Plover bay to Plover bay, would be entitled to the highest weight if the observations at Plover bay had been more successful. The longitude of Plover bay has been quite well determined, and is probably known within a very few seconds of time, ("Bulletin of Philosophical Society of Washington," vol. iv.) But unfortunately, but little reliance can be placed on the observations, which were, on account of the weather, few and unsatisfactory. They may be in error by ten or more seconds.

The two results first given are subject to the uncertainties of rate due to the length

of the voyage. It is probably impossible to conduct a chronometric expedition of one hundred and twenty days and determine the longitude thereby with an uncertainty less than many seconds. The agreement in the results as determined by the separate chronometers is as good as can be expected, though their extreme range is 43 seconds.

On the whole it seemed best to adopt the second and fourth values of the series given above, giving them equal weight. We have then the results as below, according as we use the chronometer corrections at Point Barrow determined by special sextant observations, or as given by Lieutenant Ray:—

10 h. 26 m. 34.5 s.
43.7 s.
mean 10 h. 26 m. 39 s. final value of longitude.

This value, it need hardly be said, is uncertain by at least ten seconds, but it seems as accurate as can be obtained from the data at hand. The method of chronometers is not the best when the voyage is a long one, especially when a permanent party remains for months at the station whose longitude is desired. At the latitude of Point Barrow, the longitude can be obtained by lunar distances, or still better by lunar culminations, within 5 or 6 seconds at each observation. The permanent party can, therefore, by making sufficient observations, obtain their longitude to the nearest second, a degree of accuracy which cannot be looked for in the transportation of chronometers from the United States, under the most favorable circumstances.

No. III.

REPORT OF LIEUTENANT P. HENRY RAY:

WORK AT POINT BARROW, ALASKA,

FROM SEPTEMBER 16, 1881, TO AUGUST 25, 1882.

UNITED STATES SIGNAL STATION,
OOGLAAMIE, ALASKA, *August* 25, 1882.

TO THE CHIEF SIGNAL OFFICER, U. S. A.,
Washington, D. C.

SIR: I have the honor to report that, after the sailing of the Golden Fleece on the 16th of September, 1881, the whole energies of the party were devoted to securing the stores and instruments and erection of the buildings; the weather continued very stormy and inclement all during the month of September, so our lumber and material was wet and coated with ice, adding great discomfort to the labor of building, but the rapidly forming ice on the lakes and inlets showed we had no time to lose. By the 22d of September the building was so far advanced that we moved in all the stores that were likely to become damaged by the weather, and on October 3d it was so far completed that the whole party was enabled to move in. More or less snow had fallen during this time, and the ice was five inches thick on the inlet; the sea still remained open, with no heavy ice in sight. A strong current, setting continuously to the northeast along this shore, kept the young ice from becoming solid, but the sea was covered with loose pancakes of ice as far as the eye could reach. Storms of snow and sleet continued up to late in October; during that time we had several severe westerly gales, sending in a heavy sea on this shore. One on September 17th raised the water four and one-half feet above mean low tide, and, running clear over the long sand split between us and Point Barrow, making the little patch of dry land on which the village of Noowook stands virtually an island, and showing us that there was not a single place between the station and the extreme point where it would have been safe to build the observatory, without carrying our stores a long distance back from the beach, which it was impossible to do with my small party. There was never a time after the Golden Fleece sailed, and before the sea was closed by ice, that it would have been possible for us to have landed with our stores. As it was, there was not a pound of stores lost or damaged, or an instrument injured. I send a map of the country in the immediate vicinity of the station, with plan of buildings.

The inside work on the main building was completed after the party moved in, and at the same time the meteorological instruments were placed and hourly observations in that department were commenced October 17th. The three magnetic instruments were mounted on wooden piers, the season being too far advanced to place masonry. Posts twelve inches square were set into the frozen earth to a depth of one foot, and cemented into their place by pouring water around them and allowing it to freeze. These piers answered every purpose, were perfectly solid and did not change their position in the slightest degree; and when the observatory was

taken down this summer, I found the ice around their base unmelted. As soon as the weather was warm enough, brick piers capped with stone were placed, and the instruments are now all in position on permanent piers.

On December 1, 1881, hourly observations were commenced in the three elements of magnetism, and were kept up uninterruptedly until July 22, 1882, when the work was suspended for seven days, while moving the observatory and placing the instruments on new piers, so as to be fully prepared for the year commencing August 1, 1882. The galvanometer was placed the latter part of July, and observations commenced August 11. The location of the observatory is such, that but one ground, the east, is on land, the south being in the lagoon, and the north and west in the sea (see map.) The east ground is in oil; all the others are held by a box of gravel strapped with iron, to which the plates are attached. It was impossible to place this instrument before, as the earth was frozen so hard the wires could not be laid, and there were no poles to be had to string the wires in the air.

There has been no tidal observations owing to the fact that no gauge was furnished the expedition, and it would be almost impossible to make any ordinary gauge, such as I might construct here, remain in place at this station. The inlet near the station is not affected by the tide, except when it is open to the sea, which is only about two months during the year. A gauge placed on the beach could not be made to stand when the sea is open, owing to the heavy sea during westerly gales, and in the early winter it would be disarranged by the ice. I believe though, I will be able to get observations for one term in each year, between the months of March and June, and I shall build a gauge if none is sent this year.

NATURAL HISTORY.

In this department every effort has been made to make the collection as perfect as possible. All of the spare time of every member of the party has been devoted to this work, and to Doctor Oldmixon, especially, the department of botany and ethnology. All collections made during the past year, I send by return vessel. In the ethnological department, we have had many difficulties to contend with, as not a single member of the party could speak a word of the language of these people when we landed, but as several of the party are acquiring it rapidly, I am in hopes to be able to make a satisfactory report upon our return.

The supply of fresh meat is limited, but sufficient can always be obtained for a party of this size. Reindeer and seal only can be depended upon. We have seen but one or two walrus. During the summer a few reindeer come as far north as the station, but cannot be found in any number this side of Dease inlet, or North Refuge inlet, and during the winter, they can not be found north of latitude 70°. Seal can be taken all through the winter, after the sea closes, by means of nets, set, after the the manner of the natives, at their breathing holes. The meat of the white whale, I find to be excellent for food; have killed one this summer, and am in hopes to be able to take more, and also to get to the eastward and kill deer enough to last us through the winter, should the supply vessel reach us in time to permit me to make the trip after her departure. Last fall I purchased about five hundred pounds from the natives before the winter set in.

There is no fuel to be obtained in this vicinity, except drift; that which is indigenous to this country and comes ashore is a very inferior quality, being mostly of a species of cottonwood or balm. Even the natives can not make it burn without pouring oil over it. A few remnants of old wrecks are lying along the coast, but none of any importance near the station, and even where I have tried to get at them, they are so buried in the sand, that the labor was very great; what little timber I obtained would be of no consequence as fuel. I have utilized all I got in

building a bastion ten feet square, and two stories high on the corner of the main building, where I have mounted the Gatling gun, and stored the ammunition.

The natives have, as a rule, behaved in a friendly manner, and those belonging to Ooglaamie especially rendered valuable assistance at the time we landed, both in landing stores from the ship in their canoes and in carrying them from the beach to the site of the station. Some of the leading men from Noowook came down last winter and demanded presents which I refused to give. At the same time they made threats to come down and clean out the station, which they have not done. I have no fears of a general open attack; first, because no native has enough followers to be able to do anything serious; second, their struggle for existence keeps them too busy to make war upon any one. The spite of the disaffected ones is aimed principally at me, owing to the fact that they have been unable to obtain their usual supply of whiskey, arms, and ammunition from the whaling fleet this year. They think I am the cause of it, and I understand have made some threats in the matter; but I shall use every precaution against surprise. So far I have kept them at a distance; have never allowed any but a very few head men to come inside of the house, and do not permit my people to go into their villages or to meddle with them in any respect.

The safety of the station would be very much increased if the law relating to the sale of contraband goods by whalemen and traders on this coast could be enforced. In the past there has been no check upon it in any way whatsoever, as we found them abundantly supplied with breach-loading arms and ammunition when we landed. The sending of the revenue-cutter into this sea a month or two after the fleet has entered is simply a farce, and from all I can learn, unless her course in the future should be different from that of the past, she had better stay away entirely. I believe the offenders in the fleet this year are confined to two or three ships. I met nearly all the masters when they first came up, and they all promised a strict compliance with the law. But in spite of all that the natives here have been drunk three different times during the last month.

I have made but two expeditions from the post during the past year. The first was made during the month of March, for the purpose of obtaining fresh meat. On the 23d of that month I left the post with a sled drawn by a team of eight dogs, accompanied by two natives with their families. We travelled along the coast on the ice southwest to the entrance of Woody inlet. We there left the sea and struck inland in a southerly direction and camped in a snow-hut, without fire, twenty-seven miles from the station, on the shore of what the natives told me was a large lake with an outlet leading into Woody inlet.

March 24th, broke camp at 5 a. m., weather cloudy, with light snow, wind southwest, very cold, traveled nearly due south, crossed during the day several large lakes and two streams flowing northeast, it being almost impossible to define their banks, as the whole country is nearly a dead level and covered with snow. I only knew when I passed from ice to land, as the natives told me. Travelled eighteen miles and went into camp at 1 p. m. Built a snow-hut to sleep in. The dry snow drifting with the wind made travelling very difficult, and it was hard work to make the dogs face the sharp wind. Camped on the left bank of a small stream flowing northeast, country along it more rolling and broken than that travelled over earlier in the day.

March 25th, broke camp at 6.30 a. m., weather still stormy, with light snow, wind southwest, travelled in a southerly direction. Very difficult to keep the course by the compass, as the guide and dogs were constantly getting out of their direction by the force of the wind, and the drifting snow hiding every landmark left us nothing to travel by, it being impossible to see but a few yards ahead of the team. After travelling about fifteen miles, came to a large river with high banks, as they were

swept clean by the wind, the river was well defined. It was two hundred yards wide at the point where I crossed it, and where the ice was exposed, seemed very winding. Its general course is northeast true. Named it Meade river, in honor of the late Major General George G. Meade, U. S. Army. A low growth of stunted willows, about four feet high, fringes its banks, it being the first growth of anything like timber seen since leaving the station. We traveled up the right bank three miles and came to the camp of a native deer-hunter named Mung-y-a-loo, who belongs at Ooglaamie. These natives, while hunting deer in the winter, never remain long in one place and live exclusively in snow-huts, which they construct very quickly whenever they wish to camp. They are simply oblong holes dug into the hard snow where it has drifted deeply, and covered with slabs of the same material, cut out with a large knife they carry for that purpose. I have never seen any of them build a circular hut, and they do not seem to know how. Camped with Mung-y-a-loo. Travelled eighteen miles.

March 26th. Broke camp at 5 a. m., travelled in a southwesterly direction along the right bank of Meade river seven and one-half miles, and crossed over to the left bank; channel two hundred and fifty yards wide at this point. At this place the trail left the river. I could see a large fork coming from the southeast, and the land was higher to the south, so I am of opinion it breaks into several forks a short distance above where I left it. Found several specimens of lignite coal among the drift on a sand bar. Natives told me that there is a large vein a few miles higher up the river. If so, it is the nearest to the station of any yet discovered. Continued to travel in about the same direction all day; saw several bands of reindeer for the first time. At 6.30 p. m., came into the camp of an Ooglaamie native named Nick-a-y-a-loo, on a small stream that, from what the natives told me, I judge flows into Wainright's inlet. Weather clear, but very cold, with strong southwest wind. The sun and the snow affecting the eyes of the whole party very much. Marched thirty-two miles.

March 27th. Laid over in camp. Purchased four reindeer, also a number of white fish. Natives tell me they caught them in Meade river. Weather very cold.

March 28th. Broke camp at 5.30 a. m. for return trip, having obtained all the venison I could haul. As the wind remained in the southwest, was enabled to use a sail on the sled, and made excellent time, reaching Mung-y-a-loo's camp at 4 p. m. Hired one native boy to return with me.

March 29th. Wind blowing a gale from the west. Native refused to travel; obliged to lay over; weather very cold.

March 30th. Wind fell during the night, but still blowing fresh from the west. Broke camp at 5 a. m., following my outward bound trail; marched twenty-seven miles, and camped in an abandoned snow-hut.

March 31st. Broke camp at 5 a. m., travelled on trail; wind fair for sailing; weather very much moderated; reached the station at 6 p. m. Travelled thirty-six miles.

On this trip, I did not carry any instrument but a compass and pocket chronometer, as the sun was too low to make observations of any value. The trip was made solely to obtain fresh meat, as I dared not allow the party to go any longer without it. I wished to test the question if I was able to travel with safety alone with these natives, and they treated me with the utmost kindness throughout the whole trip; was obliged to travel most of the time on foot to keep from freezing.

On the 28th of April, I left the station with one native and a dog-team to locate the mouth of Meade river; traveled east 23° south, forty-five miles; found that it emptied into the Arctic ocean by five mouths, in latitude 70° 59′, north; longitude 154° 32′ west; returned to the station April 30th. The wind being fair, I made the trip from the mouth of the river to the station in thirteen hours. Since then, I have been too busy with the more important work at the station to be able to leave.

The sea, after the night of November 21st, was closed without any sign of open water until the 23d of April, when a small lead was reported four miles out, northwest from Noowook. Whales were also reported, and the natives reported seeing them nearly every day during the month of May and up until the 10th of June. In January we saw what is commonly known as a water sky, extending along the horizon to the northwest. As it was very black and heavy, and seemed very near, I started out to it. After travelling between six and seven miles over the ice, the heavy cloud faded away from in front of me and was just as visible between me and the land. It was simply the moisture rising through cracks in the ice. This I found to be the case in every instance where a *water* sky was seen. There is a strong current setting along this coast to the northeast, except during a strong northeast gale, which will sometimes make a surface current to the southwest, but such a current is not of any duration, for invariably upon a change of wind to any other quarter the current returns again to its old northeast course. I tested it a number of times through the ice, when the sea was entirely closed, and always found it set to the northeast.

On June 25th, the steamer "North Star" hove in sight, working up through a small lead of open water, about nine miles from the station. When she got nearly abreast of the station, she became fast in the ice, the pack closing down upon her. Captain Herendeen and myself went off to her, and received our first mail since sailing. The ship at the time was suffering from a severe nip, and was considerably raised up. She remained in this position until July 7th, when the pressure slacked up, and she worked her way in to within three miles of the station, and again the ice closed upon her. She did not seem to suffer any until about 2 p. m. on the 8th, when suddenly we heard a great shout raised by the crew, and we could also hear her timbers breaking. In twenty minutes she was out of sight. I went off to their assistance at once with Captain Herendeen, taking our small boat to ferry across the open holes, and the crew, forty-seven all told, were all safely ashore and in camp at the station at noon on the 9th.

As they saved only a little flour and hard bread, I ordered an issue of such articles of the ration as was necessary for their subsistence. I was unable to communicate with the fleet, as the ice had forced them away to the south, but succeeded in getting the most of them on board the "Bowhead," which worked up near here on the 15th, and we sent off the last of them on the 25th.

To Captains Campbell, Cogan, Smith, Heppinstone, and Knowles, we feel we owe a special debt of gratitude in sending us fresh vegetables as soon as they could reach us, and to all the captains of the fleet we are indebted for many acts of kindness.

During the winter a shaft was put down thirteen feet for earth temperatures, (see table) and at that point a room was excavated of sufficient capacity to store 2,000 pounds of fresh meat. As the temperature is below freezing winter and summer, there is no limit to the time we can preserve it. Shall carry on the work in the coming winter.

I ship one box (twenty-four) negatives of scenes and natives in this vicinity. My short course of instruction, and want of experience, I hope will be sufficient excuse for the quality of the work, but hope they will be of some service. Would like to have some prints returned to me with an expert's advice as to the course to pursue where I have failed to make a good negative.

There are some parts of the work which I will be unable to carry out with a party so small as this; for instance, observations of the aurora from different points, also sketches of the same, as the display is never the same for two consecutive seconds.

Measurements of the ice formation taken each month on the inlet adjacent to the station, are entered on the meteorological reports. Six feet, two and a half inches was the greatest thickness attained. The heaviest ice seen was that which came

down from the north with the pack in November. Eight feet was the maximum. I am of the opinion that ice never forms beyond that depth in this sea, as we could not find that it increased in thickness perceptibly, even after the temperature of the sea fell below the freezing-point for sea-water. The ice accumulates in great masses under the pressure caused by the currents, and gales, so that it often grounds in thirty fathoms of water. These masses become so firmly cemented by frost in the winter that they do not break up until July.

There has been no sickness of any consequence in the party during the year, and all have performed their duties with commendable zeal and fidelity, and as the full work has been carried on so far with four observers, the work for the ensuing year will be lighter than that of the past.

The carpenter and cook began to show signs of breaking down, and as I was able to replace them by two excellent men from the whaling fleet, I have discharged them at their own request.

The "Leo," with Lieutenant Powell, reached here on the 20th of this month, and she was discharged by the 25th. Lieutenant Powell brought but one magnetic hut, and it is designed for pendulum observations. I shall put it up and use it for the new magnetic instruments, but I cannot be responsible for the results, as it is nailed with iron nails throughout. It is a disappointment to me that the vessel did not arrive earlier, so as to enable me to have the instruments in position for international work. It was a mistake in allowing her to stop at intermediate places with private freight. Had she not done so, she would in all probability have reached here in time. As it is, the ground is now covered with snow, and winter is upon us, rendering the work of putting up brick piers very difficult. If a vessel cannot be chartered for this service alone, it would be better to ship by the "Tender" of the whaling fleet, which sails from San Francisco in June, and generally returns early in September. I have retained all the men I have quarters for. Should more be sent next year, additional lumber should be sent to construct quarters, of which I have furnished Lieutenant Powell a memorandum. I send estimates of stores for the year ending 1884. For the errors which may be found in my work for the past year, I hope the Chief Signal Officer will take into consideration my want of previous knowledge and instruction in scientific work. I return Sergeant Cassidy by "Leo."

I am, sir, very respectfully, your obedient servant,

(Signed) P. H. RAY,

1st Lieutenant, 8th Infantry, A. S. O.,

Commanding Post.

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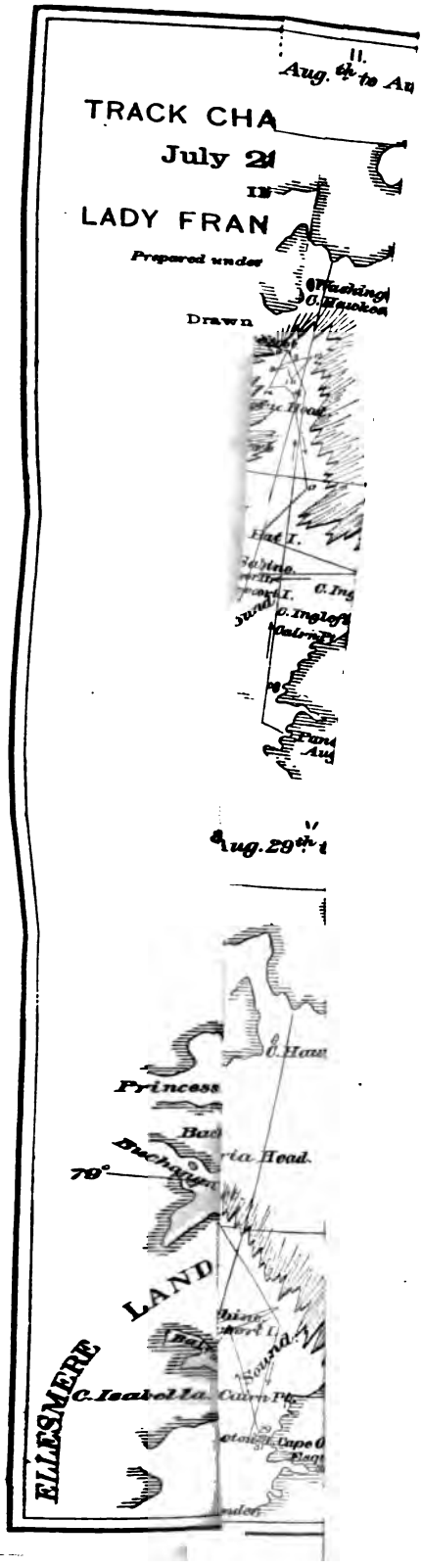
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ELLESMERE

Pam. 8

UNITED STATES OF AMERICA:
WAR DEPARTMENT.

SIGNAL SERVICE NOTES
No. VI.

REPORT ON WIND VELOCITIES

AT

THE LAKE CRIB AND AT CHICAGO.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY,

BY

H. A. HAZEN,
COMPUTER, OFFICE OF THE CHIEF SIGNAL OFFICER.

BY AUTHORITY OF THE SECRETARY OF WAR.

WASHINGTON:
OFFICE OF THE CHIEF SIGNAL OFFICER.
1883.

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WIND VELOCITIES AT THE LAKE CRIB AND AT CHICAGO.

On March 31, 1882, a self-recording anemometer was established by the Signal Service at the lake crib, a point on Lake Michigan, situated about three miles east of Chicago. These observations were kept up until September 30, 1882. It is proposed in this paper to discuss:

1st, the relative velocity of the wind at the two stations;

2d, the relative velocity as influenced by the direction of the wind, and;

3d, the relative velocity as influenced by the diurnal range of the wind.

The following data have been used in compiling this report:

1st, maximum velocity in past eight hours, at 7 a. m., 3 p. m., and 11 p. m., Washington time; movement of wind in past eight hours, at 7 a. m., 3 p. m., and 11 p. m., as above; also the total movement in each twenty-four hours; all these for the months of April, July, August, and September, 1882.—See 125 Mis. 1883.

2d, velocity in miles per hour for 7 a. m., 3 p. m., and 11 p. m., Washington time, at the lake crib and Chicago, together with the direction at Chicago, during April, May, and September, 1882. The observations are contained in table I., page 4. The direction was not observed at the lake crib. The months of April, May, and September were chosen as being the windiest of the six.

3d, diurnal range of the wind velocity at the lake crib and Chicago, for July and August, as exhibited in table II., page 6. These months were chosen as giving the most satisfactory results for diurnal range of the wind velocity.

4th, hourly *direction* of the wind at Chicago for June, July, August, and September, as shown in tables VII. and VIII.

If now we divide each mean monthly velocity at the lake crib by the same at Chicago, we shall obtain the ratio between the winds at the two places, or in other words, if we multiply the velocity at Chicago by this ratio, we shall obtain the approximate mean velocity at the lake crib. In table III. are grouped ratios as determined by various combinations. In table IV. are given the combination of all the results arranged according to the hours 7 a. m., 3 p. m., and 11 p. m.

We find, 1st, an augmentation of the ratio during the summer months, in April 1.56, July 1.64, August 1.69, September 1.32. This seems a reality, though it is much to be regretted that we have not observations for an entire year to show this more conclusively; 2d, the ratios, 1.84 at 7 a. m., 1.42 at 3 p. m., and 1.54 at 11 p. m., indicate a very large increase at the coldest part of each twenty-four hours over that at the warmest; 3d, that the mean ratio of all winds at 7 a. m., 3 p. m., and 11 p. m. is 1.59 during the six months, April to September.

In Table V. are exhibited the mean hourly wind-velocities for each hour of July and August, transcribed from Table II., and in Plate I. are shown the same results graphically.

We see, 1st, the range of the wind at the lake crib is only about half that at Chicago; 2d, that the ratio is about 2.1 in the early morning hour and diminishes to 1.3 at noon.

In order to ascertain the influence of winds from different directions, all the direction observations in Table I. have been grouped under four heads as follows: N. and NE., E. and SE., S. and SW., and W. and NW., *i. e.*, all the winds having, at Chicago, a N. or NE. direction, have had the velocity at the time of observation arranged in a column, and the velocity at the lake crib, at the same time, has been placed in a parallel column. The sums of these velocities are given in Table IX.

TABLE I.

Wind records at the lake crib and Chicago, with velocity in miles per hour.

Day of month.	April, 1882.						May, 1882.						September, 1882.					
	Lake Crib.			Chicago.			Lake Crib.			Chicago.			Lake Crib.			Chicago.		
	7 a. m.	3 p.m.	11 p.m.	7 a. m.	3 p.m.	11 p.m.	7 a.m.	3 p.m.	11 p m.	7 a.m.	3 p.m.	11 p.m.	7 a. m.	3 p.m.	11 p.m.	7 a. m.	3 p.m.	11 p.m.
1	12	20	15	sw. 12	w. 11	sw. 18	28	25	26	sw. 11	w. 13	n. 12	8	15	24	n. 3	ne. 9	se. 18
2	7	2	18	sw. 6	n. 14	n. 8	7	14	17	e. 6	se. 10	s. 5	15	.....	8	sw. 8	w. 8	sw. 5
3	21	27	33	se. 9	se. 6	sw. 10	23	16	18	s. 7	s. 12	sw. 10	.....	.....	13	sw. 4	w. 8	w. 6
4	11	6	15	sw. 9	n. 13	n. 12	9	10	20	sw. 4	se. 8	n. 12	15	14	4	nw. 6	ne. 9	ne. 2
5	24	43	17	ne. 14	ne. 12	e. 10	21	12	19	ne. 16	ne. 11	ne. 22	6	8	7	nw. 3	e. 9	se. 4
6	.....	.....	.....	s. 10	sw. 24	w. 8	25	15	15	ne. 20	ne. 16	ne. 14	7	8	2	se. 4	sw. 8	sw. 4
7	.....	10	17	n. 4	ne. 12	ne. 8	18	10	12	ne. 8	ne. 12	e. 10	6	8	9	sw. 5	sw. 4	ne. 7
8	16	7	21	e. 10	ne. 8	e. 12	16	12	15	se. 8	s. 12	s. 12	3	16	16	ne. 2	ne. 12	ne. 8
9	21	10	.....	e. 15	ne. 10	ne. 16	18	21	16	s. 10	sw. 16	se. 7	5	5	3	se. 2	e. 8	e. 4
10	19	60	.....	ne. 20	n. 18	ne. 15	12	4	15	s. 4	w. 6	n. 9	25	29	.....	ne. 9	n. 13	ne. 14
11	.....	.....	.....	nw. 10	n. 11	ne. 8	19	24	18	ne. 10	ne. 16	ne. 14	28	17	.....	ne. 13	ne. 10	ne. 8
12	.....	10	18	nw. 4	ne. 9	n. 6	18	32	35	ne. 12	ne. 18	ne. 16	.....	.....	.....	se. 6	se. 11	s. 10
13	.....	8	5	n. 4	ne. 10	ne. 6	28	34	37	ne. 12	n. 12	n. 6	23	12	8	s. 7	sw. 8	sw. 6
14	13	6	7	n. 4	ne. 10	nw. 3	20	29	21	n. 12	n. 20	n. 16	16	20	11	w. 6	w. 15	w. 4
15	11	9	8	nw. 2	e. 10	s. 6	31	25	18	n. 8	n. 14	n. 5	14	10	8	ne. 7	e. 11	se. 8
16	14	6	7	w. 4	w. 7	w. 7	9	11	0	n. 4	n. 8	o o	8	6	9	s. 4	se. 8	s. 8
17	15	14	11	sw. 2	se. 8	s. 8	7	6	5	nw. 5	e. 7	s. 2	11	8	8	sw. 6	sw. 14	sw. 6
18	6	11	22	s. 6	s. 10	s. 13	1	6	15	e. 2	e. 8	se. 8	6	13	7	sw. 10	s. 18	sw. 12
19	34	44	15	sw. 14	w. 24	nw. 8	15	13	11	se. 6	sw. 6	se. 5	21	.....	.....	w. 13	sw. 12	w. 4
20	21	5	3	nw. 8	ne. 8	e. 4	9	20	18	s. 7	s. 13	w. 9	.....	.....	15	nw. 6	nw. 10	nw. 4
21	7	7	18	e. 6	ne. 11	ne. 19	16	29	22	w. 8	w. 20	w. 12	8	17	14	nw. 6	nw. 10	w. 5
22	19	24	34	e. 11	e. 14	ne. 23	12	24	14	w. 7	w. 16	nw. 8	13	16	9	w. 6	sw. 13	sw. 5
23	22	27	26	e. 20	ne. 15	ne. 16	15	13	11	nw. 6	e. 12	se. 5	14	11	8	w. 5	ne. 9	ne. 3
24	14	14	13	e. 9	ne. 12	ne. 10	15	5	8	se. 6	nw. 3	e. 4	11	11	13	s. 4	ne. 11	e. 8
25	19	10	15	se. 11	ne. 13	ne. 8	0	8	7	ne. 2	e. 8	se. 4	14	18	14	e. 9	ne. 14	e. 9
26	28	22	7	e. 18	e. 12	e. 6	6	11	8	sw. 6	e. 8	ne. 7	15	16	16	ne. 11	ne. 14	e. 10
27	5	14	10	w. 7	w. 11	w. 4	10	25	24	ne. 12	n. 16	n. 10	9	16	20	e. 7	e. 12	se. 11
28	13	7	2	nw. 7	se. 4	w. 4	28	30	21	n. 12	n. 16	n. 9	4	8	16	se. 5	e. 9	se. 11
29	10	8	18	nw. 5	se. 8	w. 9	16	5	8	n. 7	e. 6	se. 6	11	7	6	se. 8	se. 8	se. 6
30	25	10	17	n. 8	se. 8	sw. 8	7	23	27	s. 7	sw. 15	s. 15	3	6	9	nw. 3	ne. 6	ne. 6
31							24	28	21	sw. 12	n. 16	n. 9	.....	.....	.....	.....	.....	.....
Means	16.3	15.8	15.1	9.0	11.4	9.6	15.6	17.4	16.8	8.3	12.1	9.1	11.1	12.6	10.6	6.3	10.4	7.2

TABLE II.

Diurnal range of wind velocity, Chicago, Illinois, thirty days of July, 1882.

Day of month.	Midn't.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
1	8	6	6	5	3	1	2	4	4	7	7	9	10	12	11	14	13	12	13	9	9	8	8	8
2	12	11	11	9	10	7	6	6	5	7	6	6	7	8	7	7	6	6	6	5	4	4	3	3
3	3	2	2	3	2	2	3	7	6	7	9	8	10	8	9	7	10	9	14	12	13	13	11	11
4	10	9	11	9	9	7	8	10	13	12	11	14	15	14	16	15	14	16	14	13	12	9	10	10
5	7	5	5	9	7	6	6	6	10	9	10	10	11	7	8	8	8	8	7	5	4	3	2	2
6	2	3	4	4	4	4	5	4	6	6	7	8	9	9	8	9	10	10	10	10	9	8	8	7
7	9	8	7	11	9	11	10	11	12	12	10	13	15	14	15	13	13	10	9	10	9	8	6	7
8	9	8	7	7	6	5	5	4	5	5	4	7	6	7	8	8	7	6	6	4	5	5	3	2
9	2	3	4	4	2	4	4	4	4	5	6	8	11	12	12	11	11	13	11	10	10	10	10	9
10	7	7	7	7	8	7	8	6	4	3	4	5	7	8	10	11	13	14	13	13	10	9	9	9
11	10	10	10	9	7	9	10	12	11	13	13	12	15	13	14	15	14	15	13	9	8	7	5	5
12	6	5	6	6	8	4	6	6	6	8	9	13	14	12	10	11	11	11	13	10	9	7	7	7
13	8	6	6	6	6	6	5	5	5	5	4	3	8	8	6	8	4	7	6	6	7	4	3	4
14	3	3	4	3	3	3	3	2	3	5	6	8	9	9	8	8	7	8	9	8	6	5	5	4
15	4	4	5	5	4	6	6	8	8	9	10	9	10	10	10	10	11	9	11	7	6	6	6	9
16	8	9	11	12	16	13	12	10	14	14	12	15	15	15	16	14	13	12	12	9	7	6	7	7
17	6	9	8	7	6	4	5	5	6	3	6	7	8	7	9	8	7	6	7	5	6	6	6	4
18	4	6	8	8	7	9	7	6	8	10	11	9	9	8	7	8	7	5	8	8	6	6	5	6
19	8	7	6	6	5	5	6	5	6	8	6	7	7	6	6	9	10	9	9	9	7	5	4	2
20	2	2	3	3	4	5	4	5	5	3	3	5	7	8	8	8	8	7	4	4	4	3	2	2
21	3	3	5	5	4	4	4	4	3	4	7	7	6	7	8	7	8	6	6	6	4	2	2	2
22	2	2	2	4	4	4	3	2	3	5	6	6	7	8	7	8	9	7	6	4	5	5	3	3
23	4	4	4	4	4	3	4	6	5	6	5	4	5	6	8	6	6	7	7	4	4	4	4	5
24	4	5	5	6	4	4	4	5	5	5	7	8	9	9	9	8	8	8	9	7	6	4	5	5
25	4	4	4	3	4	4	4	5	3	6	6	7	9	10	9	9	9	8	8	7	6	5	5	5
26	7	6	7	7	6	5	5	4	7	8	8	8	9	10	9	10	9	10	9	8	5	4	5	6
27	6	6	6	7	6	7	7	8	9	11	10	12	13	15	15	18	17	17	15	12	9	5	9	7
28	5	5	5	4	4	4	3	4	4	5	8	9	12	10	10	11	12	11	11	12	11	11	11	8
29	9	10	10	10	9	7	7	7	9	10	11	10	11	11	11	10	11	9	9	9	9	7	7	8
30	9	10	7	7	8	9	10	12	11	10	11	9	8	9	10	8	10	9	10	8	7	9	8	12
Total	181	178	186	190	176	169	173	183	200	221	233	256	292	290	294	297	296	285	285	243	217	188	179	179
Mean Chicago	6.0	5.9	6.2	6.3	5.9	5.6	5.8	6.1	6.7	7.4	7.8	8.5	9.7	9.7	9.8	9.9	9.9	9.5	9.5	8.1	7.2	6.3	6.0	6.0
Mean lake crib	12.1	12.0	12.3	12.4	12.1	11.5	11.4	11.2	11.9	12.1	11.4	11.1	12.2	12.8	13.5	13.0	13.2	13.5	13.8	12.3	11.0	11.3	11.4	11.8
Ratio	2.02	2.03	1.98	1.97	2.05	2.05	1.99	1.84	1.78	1.64	1.46	1.31	1.26	1.32	1.38	1.31	1.33	1.42	1.45	1.52	1.53	1.79	1.90	1.97

TABLE III.

Diurnal range of wind, at the lake crib, three miles east of Chicago, Illinois, thirty days of July, 1882.

Day of month.	Midn't.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
1	27	25	15	10	6	7	6	7	6	8	6	6	5	5	5	0	3	2	2	1	3	4	3	5
2	5	2	3	7	4	2	8	16	8	14	13	15	11	13	16	17	16	11	27	14	15	31	28	24
3	28	26	25	24	24	21	25	27	28	26	28	30	30	30	30	29	29	28	28	27	25	24	26	23
4	25	23	26	25	22	20	17	20	22	22	21	19	16	14	13	11	8	5	3	1	0	2	2	4
5	4	6	7	7	8	9	12	11	12	13	10	12	13	16	13	15	15	19	19	19	14	13	13	13
6	15	16	15	25	20	22	22	24	26	24	21	27	34	32	28	29	27	22	16	18	17	16	14	11
7	14	14	13	11	11	8	9	5	7	7	6	6	9	5	9	5	5	3	2	2	2	1	3	3
8	1	2	3	4	2	3	3	4	6	9	10	14	3	4	6	8	11	13	14	19	19	17	16	25
9	15	14	14	13	14	13	15	9	15	12	21	2	6	6	15	16	20	24	23	21	20	22	23	22
10	23	21	18	16	15	16	17	19	18	18	22	20	19	19	22	21	23	24	21	17	13	12	10	12
11	11	11	12	13	16	11	8	14	14	16	13	21	21	18	15	15	15	17	24	15	13	16	14	13
12	15	13	13	12	14	14	13	12	10	7	14	3	7	7	7	10	8	11	12	3	1	0	5	9
13	17	18	10	11	11	14	11	9	4	6	6	2	6	8	8	8	9	9	(10)	(10)	11	12	11	9
14	9	9	9	9	11	15	13	18	18	15	15	14	13	14	13	14	10	14	14	13	11	10	12	14
15	14	15	20	30	34	29	23	21	28	33	27	26	28	26	28	25	22	20	18	17	14	14	15	17
16	16	15	14	14	11	7	7	10	9	4	2	6	3	5	6	8	6	8	6	2	5	7	11	9
17	3	5	9	9	10	9	11	8	8	6	4	3	5	4	6	5	6	5	4	4	1	0	2	3
18	4	3	4	5	7	6	6	5	7	9	5	5	3	7	7	6	7	8	7	5	4	5	5	6
19	6	7	8	6	7	8	11	10	9	6	1	2	6	8	9	10	10	9	9	8	8	6	8	8
20	9	9	11	10	10	8	6	8	6	9	8	10	14	14	12	10	9	12	12	12	12	8	8	8
21	9	9	8	6	5	5	7	4	9	8	7	7	12	16	14	14	9	9	9	10	10	7	8	7
22	9	12	15	18	13	10	10	7	11	13	14	9	12	14	15	13	14	14	13	12	9	8	10	13
23	15	15	15	14	16	18	17	18	18	19	18	19	23	25	26	30	30	31	26	20	13	7	17	11
24	13	13	5	7	10	6	3	4	10	13	14	14	17	18	19	20	20	25	26	26	20	27	26	26
25	20	16	18	13	9	9	9	11	12	11	9	11	13	13	13	8	10	8	9	9	13	11	9	7
26	8	11	14	14	13	15	17	21	19	16	17	14	11	13	14	13	15	12	9	11	14	16	15	20
27	21	21	21	19	18	21	19	21	17	16	15	12	12	10	13	15	12	9	12	12	9	9	8	6
28	4	5	4	2	4	4	2	4	2	1	5	3	4	7	11	9	8	10	12	12	7	4	2	4
29	4	9	14	10	6	3	6	3	5	6	9	6	3	5	3	1	6	9	13	17	14	9	9	13
30	9	4	5	7	12	13	10	7	4	5	2	5	6	7	8	6	8	14	13	9	8	15	9	10
Total	363	359	368	371	362	346	343	337	358	362	343	333	365	383	404	391	397	405	413	368	331	339	342	355
Mean	12.1	12.0	12.3	12.4	12.1	11.5	11.4	11.2	11.9	12.1	11.4	11.1	12.2	12.8	13.5	13.0	13.2	13.5	13.8	12.3	11.0	11.3	11.4	11.8

TABLE IV.

Diurnal range of wind, Chicago, Illinois, thirty days of August, 1882.

Day of month.	Midn't.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
1	5	5	5	4	2	3	2	4	4	3	3	6	5	7	8	8	9	8	8	10	6	6	4	3
2	5	5	5	4	2	3	3	3	3	5	5	5	6	5	4	3	5	8	7	8	8	7	6	6
3	5	4	3	3	3	5	4	3	4	5	4	9	8	8	10	9	10	8	8	9	8	7	7	5
4	5	5	6	7	10	7	9	8	9	7	8	6	7	7	9	8	11	9	8	9	6	5	6	4
5	3	3	5	5	4	5	4	4	3	5	6	6	7	9	7	6	6	7	7	7	8	6	4	4
6	3	4	3	5	3	2	1	2	2	2	3	4	5	8	7	5	6	6	6	4	3	3	2	3
7	3	2	4	3	3	2	4	3	5	5	6	6	5	7	9	10	10	11	6	8	6	8	3	5
8	5	5	5	6	5	6	7	8	8	9	11	11	10	13	13	14	14	12	11	11	9	7	6	9
9	4	3	5	4	6	5	5	5	5	6	6	6	8	9	10	7	12	10	12	9	8	6	8	8
10	6	7	7	8	7	6	5	5	8	8	8	6	7	8	9	9	8	8	7	6	5	5	4	3
11	4	4	4	3	5	5	5	5	6	7	9	9	9	9	9	9	10	10	11	9	8	6	7	7
12	9	9	10	10	8	9	9	10	10	11	12	12	14	13	14	14	13	16	10	9	7	6	5	4
13	3	3	2	2	4	7	6	9	8	8	6	7	9	10	11	10	10	8	8	9	7	7	7	9
14	8	9	9	9	9	9	8	9	10	9	9	12	10	11	12	13	14	15	13	12	9	6	5	9
15	12	12	10	6	6	5	5	6	9	7	7	7	8	7	12	11	12	11	9	7	6	6	5	8
16	6	8	6	5	5	5	5	5	6	6	6	10	10	10	8	9	10	10	8	9	7	6	5	6
17	4	4	3	4	4	4	4	5	7	9	9	9	8	9	9	9	8	8	9	7	6	6	4	5
18	3	3	4	3	4	3	4	3	3	6	6	7	7	8	8	9	9	9	6	6	5	2	3	3
19	2	3	3	3	4	5	5	5	6	8	6	8	8	7	10	10	10	8	5	8	6	5	3	4
20	3	3	4	5	5	5	3	4	5	6	6	10	8	8	7	6	6	5	6	6	3	2	2	2
21	3	4	3	4	4	4	4	7	5	7	9	10	11	10	9	8	9	9	9	7	5	5	6	5
22	7	5	5	6	5	5	6	6	7	7	7	9	9	9	8	9	11	8	4	6	5	5	4	4
23	8	2	6	8	7	7	5	5	6	6	5	4	7	8	9	8	8	8	8	9	6	9	7	7
24	4	5	5	4	2	5	4	3	5	5	6	8	6	7	8	7	9	6	6	7	6	2	2	2
25	2	3	3	3	2	3	4	2	1	4	3	7	6	6	7	6	6	6	4	4	2	3	2	1
26	3	4	5	4	4	3	4	5	6	9	7	7	6	7	9	11	10	11	10	10	11	10	10	9
27	7	6	7	8	6	7	7	9	8	10	11	11	10	11	14	15	13	11	10	11	8	10	8	7
28	7	7	10	8	6	6	6	7	8	11	10	10	11	12	13	14	13	13	10	10	8	9	9	8
29	12	8	7	8	8	8	10	12	10	10	10	9	9	9	9	9	8	9	8	8	8	8	6	6
30	7	7	6	7	6	6	6	6	6	8	6	5	7	6	8	10	8	4	5	6	6	6	4	3
Total	158	152	160	159	150	156	154	168	183	209	210	236	241	258	280	276	288	272	239	241	196	179	154	159
Mean Chicago	5.3	5.1	5.3	5.3	5.0	5.2	5.1	5.6	6.1	7.0	7.0	7.9	8.0	8.6	9.3	9.2	9.6	9.1	8.0	8.0	6.5	6.0	5.1	5.3
Mean Lake Crib	10.8	10.4	10.6	11.4	10.9	11.5	11.2	11.7	11.5	12.2	11.3	11.6	11.1	12.0	12.8	13.2	13.8	13.3	12.4	12.9	11.7	10.4	9.7	10.3
Ratio	2.04	2.04	2.00	2.24	2.18	2.21	2.19	2.09	1.89	1.74	1.61	1.47	1.39	1.40	1.38	1.43	1.44	1.46	1.55	1.61	1.80	1.73	1.90	1.94

TABLE V.

Hourly velocity of wind, at the lake crib, thirty days of August, 1882.

Day of month.	Midn't.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
1	5	5	4	2	4	4	2	4	2	1	5	3	4	7	11	9	8	10	12	12	8	4	2	4
2	4	9	14	10	6	3	6	3	5	6	9	6	3	5	3	1	6	9	13	17	14	9	9	13
3	9	4	5	7	12	13	10	7	4	5	2	5	6	7	8	6	8	14	13	9	8	15	9	10
4	11	9	5	10	11	13	14	14	14	12	11	10	8	9	11	12	10	5	10	9	6	4	4	4
5	3	3	3	5	5	8	7	4	3	5	7	5	4	5	9	11	12	10	9	11	11	3	5	4
6	8	12	12	11	6	6	3	5	5	6	5	3	2	4	6	7	3	3	10	4	6	5	3	6
7	5	5	6	4	4	3	4	6	5	6	5	6	2	4	6	13	14	15	11	18	18	14	8	9
8	11	8	11	12	12	12	15	18	17	19	21	24	28	29	28	29	25	20	20	19	16	18	20	18
9	14	13	14	14	16	18	16	14	13	11	8	9	13	20	15	16	25	21	17	17	20	18	23	22
10	18	20	24	26	21	20	19	21	19	17	15	12	11	8	10	12	10	11	8	8	10	9	9	9
11	12	11	12	11	10	11	10	14	16	18	18	15	14	12	13	16	16	18	19	17	14	17	18	16
12	20	20	22	21	21	23	20	22	22	25	24	26	27	26	25	27	29	25	12	16	10	9	8	6
13	4	3	5	4	6	12	13	15	15	12	9	11	11	18	15	18	18	16	15	14	13	10	13	15
14	17	18	20	21	21	23	21	23	22	22	18	21	18	17	18	22	25	28	27	25	17	12	10	17
15	28	26	21	14	12	12	9	12	13	13	11	15	14	18	25	22	25	17	17	15	12	10	10	17
16	17	19	17	14	13	12	13	14	14	10	10	8	9	12	8	7	7	0	9	12	14	10	6	4
17	8	8	8	10	12	12	13	12	9	8	7	13	6	6	9	7	8	10	8	8	11	12	7	11
18	6	3	3	5	7	7	9	6	7	6	7	7	6	6	7	10	12	10	8	7	7	4	5	7
19	4	6	7	9	9	10	9	10	10	14	12	13	12	13	16	16	19	13	6	11	12	10	7	6
20	6	7	9	12	9	10	8	9	10	12	12	15	12	11	9	7	11	9	7	8	6	4	5	7
21	8	8	9	7	7	5	9	15	12	15	14	19	19	16	12	12	11	15	13	11	9	8	9	9
22	9	12	10	13	13	12	10	8	9	12	8	11	16	15	12	14	15	17	9	7	11	11	6	6
23	15	6	9	16	12	15	11	6	10	9	6	5	6	11	14	13	11	12	15	15	11	15	12	11
24	8	7	5	6	3	5	5	6	6	6	8	9	7	6	6	6	7	7	7	7	7	2	1	2
25	5	2	5	5	3	5	3	5	3	3	3	6	8	9	9	9	11	8	4	8	4	1	5	1
26	7	9	7	8	7	8	8	7	10	10	13	8	9	12	16	14	11	17	19	22	23	24	19	20
27	15	9	7	18	17	18	19	19	20	21	20	19	12	12	12	12	15	15	17	19	9	11	18	18
28	16	15	18	18	15	14	17	15	16	18	21	16	20	20	22	19	17	18	18	19	18	18	17	19
29	17	17	14	15	16	17	18	20	21	19	16	15	13	13	14	13	12	11	12	14	14	14	13	12
30	13	17	13	13	16	15	14	17	14	18	14	14	13	9	14	16	11	9	8	8	12	10	10	7
Total	323	311	319	341	326	346	335	351	346	365	339	349	333	360	383	396	413	399	373	387	351	311	291	310
Mean	10.8	10.4	10.6	11.4	10.9	11.5	11.2	11.7	11.5	12.2	11.3	11.6	11.1	12.0	12.8	13.2	13.8	13.3	12.4	12.9	11.7	10.4	9.7	10.3

TABLE VI.

Relative wind velocities at the lake crib and Chicago in 1882.

		Maximum velocity in past 8 hours.						Movement in past 8 hours.						Monthly movement.		Mean of all.	Velocity at—					
		7 a. m.		3 p. m.		11 p. m.		7 a. m.		3 p. m.		11 p. m.					7 a. m.		3 p. m.		11 p. m.	
		Vel.	Ratio	Vel.	Ratio	Vel.	Ratio	Vel.	Ratio	Vel.	Ratio	Vel.	Ratio	Vel.	Ratio		Vel.	Ratio	Vel.	Ratio	Vel.	Ratio
April	Lake Crib	23.0	1.71	24.8	1.65	22.3	1.54	122.2	1.58	126.2	1.45	122.3	1.54	8,935	1.56	1.58	16 3	1.81	15.8	1.45	15.1	1.52
	Chicago	13.5		15.0		14.5		77.1		86.9		79.5		5,740			9.0		11.4		9.6	
July	Lake Crib	19.0	2.07	18.4	1.49	18.3	1.49	97.4	1.97	104.3	1.48	98.3	1.55	8,401	1.64	1.67	(15.6	1.88	17.4	1.44	16.8	1.85) May.
	Chicago	9.2		12.3		12.3		49.4		70.4		63.4		5,130			8.3		12.1		9.1	
August	Lake Crib	16.1	2.01	17.3	1.56	18.6	1.65	87.3	2.09	92.6	1.48	92.1	1.61	8,185	1.69	1.73	.....	.....	.....	.....	.....	.....
	Chicago	8.0		11.1		11.3		41.8		62.4		57.2		4,854			.....		.....		.....	
September	Lake Crib	16.0	1.65	15.1	1.28	16.1	1.34	90.7	1.68	77.9	1.13	89.1	1.29	6,633	1.32	1.38	11.1	1.76	12.6	1.21	10.6	1.47
	Chicago	9.7		11.8		12.0		54.1		69.0		68.7		5,042			6.3		10.4		7.2	
Mean		.....	1.86	.....	1.50	.....	1.50	.....	1.83	.....	1.38	.....	1.50	.....	1.55	1.59	.....	1.82	.....	1.37	.....	1.61

TABLE VII.

Combination of the mean ratios for 7 *a. m.*, 3 *p. m.*, *and* 11 *p. m.*, *in Table VI.*

	7 a. m.	3 p. m.	11 p. m.	Mean.
Maximum velocity in past 8 hours	1.86	1.50	1.50	1.62
Movement in past 8 hours	1.83	1.38	1.50	1.57
Velocity at 7 a. m., 3 p. m., and 11 p. m.	1.82	1.37	1.61	1.57
Mean	1.84	1.42	1.54	1.59

TABLE VIII.

Diurnal range of wind at the lake crib and Chicago.

	Midn't.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
July, 1882.																								
Chicago	6.0	5.9	6.2	6.3	5.9	5.6	5.8	6.1	6.7	7.4	7.8	8.5	9.7	9.7	9.8	9.9	9.9	9.5	9.5	8.1	7.2	6.3	6.0	6.0
Lake Crib	12.1	12.0	12.3	12.4	12.1	11.5	11.4	11.2	11.9	12.1	11.4	11.1	12.2	12.8	13.5	13.0	13.2	13.5	13.8	12.3	11.0	11.3	11.4	11.8
Ratio	2.02	2.03	1.98	1.97	2.05	2.05	1.99	1.84	1.78	1.64	1.46	1.31	1.26	1.32	1.38	1.31	1.33	1.42	1.45	1.52	1.53	1.79	1.90	1.97
August, 1882.																								
Chicago	5.3	5.1	5.3	5.3	5.0	5.2	5.1	5.6	6.1	7.0	7.0	7.9	8.0	8.6	9.3	9.2	9.6	9.1	8.0	8.0	6.5	6.0	5.1	5.3
Lake Crib	10.8	10.4	10.6	11.4	10.9	11.5	11.2	11.7	11.5	12.2	11.3	11.6	11.1	12.0	12.8	13.2	13.8	13.3	12.4	12.9	11.7	10.4	9.7	10.3
Ratio	2.04	2.04	2.00	2.24	2.18	2.21	2.19	2.09	1.89	1.74	1.61	1.47	1.39	1.40	1.38	1.43	1.44	1.46	1.55	1.61	1.80	1.73	1.90	1.94
Mean Ratio	2.03	2.04	1.99	2.10	2.12	2.13	2.09	1.96	1.84	1.69	1.54	1.39	1.32	1.36	1.38	1.37	1.38	1.44	1.50	1.56	1.66	1.76	1.90	1.96

PLATE I.

Diurnal range of wind velocity at the lake crib and at Chicago.

The space between two horizontal lines equals .4 miles per hour.

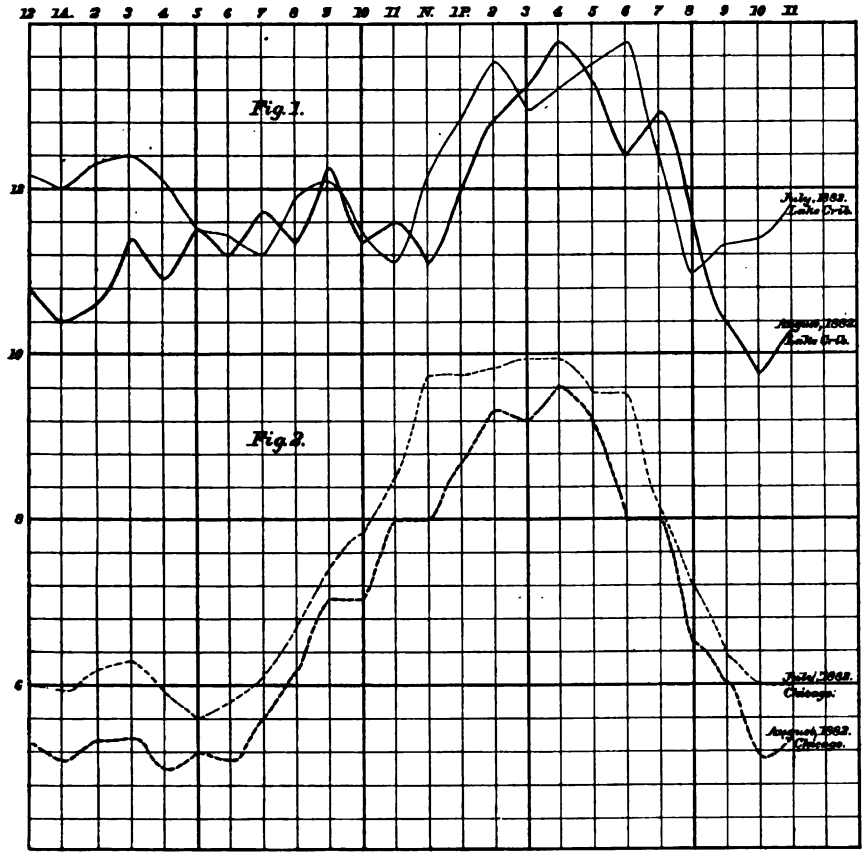

12 1A. 2 3 4 5 6 7 8 9 10 11 N. 1P. 2 3 4 5 6 7 8 9 10 11
Fig. 1.
Fig. 2.
12
10
8
6
July, 1862. Lake Crib.
August, 1862. Lake Crib.
July, 1862. Chicago.
August, 1862. Chicago.

TABLE IX.

Total wind velocities at the lake crib and Chicago during April, May, and September, 1882, arranged according to directions.

	N. and NE.	E. and SE.	S. and SW.	W. and NW.	Remarks.
Lake Crib	1,580	778	713	594	Sums of the velocities.
Chicago	982	541	463	322	
Ratio	1.61	1.44	1.54	1.84	
Number of winds	88	65	53	42	
Mean velocity Lake Crib	17.9	12.0	13.5	14.1	Miles per hour.
Mean velocity Chicago	11.2	8.3	8.7	7.7	

This table IX seems to indicate a marked decrease in the ratio with E. and SE. and S. and SW. winds. Professor Ferrel has suggested that this may be explained on the supposition of land and lake breezes *i. e.* if during the day there is a lake breeze the station on the lake would be little affected while that in the city much more, but at night, even if there were a land breeze as the wind dies down, the effect at either station would be slight.

In order to determine the mean hourly direction of the wind we may take the hourly directions, as recorded at Chicago, and find the mean direction for the month by the use of Lambert's formula. These observations for the months June, July, August, and September, 1882, have been collated in tables X., XI., XII., XIII., XIV., and XV. Table XVI. shows the mean hourly direction of the wind at Chicago by Lambert's formula, and Plate II. gives a graphical representation of the same.

From Figure 7 we see that there is a marked land and lake breeze at Chicago; during the latter part of the night and in the morning the wind blows from the west and southwest, while during the afternoon the direction is from the east and northeast. This affords another partial explanation of the great diminution of the wind velocity at Chicago during the night hours, in that the wind blows over the city and is retarded by the buildings in its path.

TABLE X.

Chicago wind direction, June, 1882. In this table 1 = N.; 2 = NE.; 3 = E.; 4 = SE.; 5 = S.; 6 = SW.; 7 = W.; 8 = NW.

Day of month.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	Midn't.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.
1	2	1	1	2	8	1	2	1	1	1	1	8	8	8	8	8	8	8	7	6	6	6	7	6
2	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	4
3	4	3	3	4	3	3	3	3	3	3	2	1	2	2	2	2	1	1	1	3	3	3	3	8
4	8	8	8	8	8	8	8	8	8	7	8	7	8	7	7	7	7	7	7	8	8	7	7	8
5	8	3	8	8	1	1	8	8	8	7	7	7	7	7	7	7	7	7	7	7	7	8	8	7
6	2	3	3	4	4	4	4	4	4	5	6	6	6	6	6	7	7	7	7	7	7	7	7	7
7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
8	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
9	6	6	6	6	6	6	6	6	6	6	6	6	7	8	8	1	2	2	3	3	4	4	3	3
10	3	3	2	2	2	2	2	2	3	3	3	3	3	4	4	5	6	6	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	2	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
13	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	3	3	3
14	3	2	2	2	3	3	3	3	4	4	5	5	5	5	5	5	5	5	5	6	6	6	5	6
15	6	6	6	6	6	6	6	7	6	6	6	5	7	7	7	7	7	7	7	7	7	7	7	6
16	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6
17	6	6	5	8	2	5	5	6	6	6	6	6	6	6	6	6	6	6	7	6	6	7	6	5
18	1	2	2	1	1	2	2	2	2	2	2	2	2	2	3	3	3	5	6	6	6	6	6	6
19	6	6	6	6	6	6	7	7	7	7	7	8	8	1	1	1	1	1	1	1	1	1	1	2
20	2	1	2	2	1	1	2	1	2	2	2	2	2	3	3	3	3	3	3	3	4	3	3	3
21	3	3	3	3	3	3	3	3	3	3	3	3	4	4	3	3	3	3	3	3	3	3	3	3
22	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	2	2	2	2	3	3	3	3	3
23	4	4	4	6	5	5	5	5	6	7	8	8	6	8	2	8	8	5	5	6	6	6	6	6
24	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	6	6	6	6	6	6
25	1	2	2	4	5	5	5	5	5	6	6	6	1	1	7	7	6	6	6	6	6	7	6	7
26	2	2	2	2	6	6	8	8	8	1	2	2	2	7	8	8	8	8	8	1	1	1	2	2
27	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4
28	4	4	4	5	6	2	4	4	4	4	4	4	3	3	3	3	2	1	1	2	1	1	1	1
29	1	1	3	3	2	2	2	1	1	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2
30	2	1	2	2	2	2	2	2	2	3	3	3	3	4	4	4	3	5	6	6	6	6	6	7
Summation.																								
N	4	5	2	2	5	5	2	5	4	5	3	3	3	4	3	4	4	5	5	3	4	4	3	2
NE	8	8	11	10	7	8	9	5	5	4	7	6	7	5	5	4	5	4	4	5	3	3	4	5
E	4	4	4	2	3	3	3	4	4	5	4	4	4	3	5	5	5	2	3	4	3	4	5	5
SE	3	2	2	3	1	1	2	2	3	2	1	1	1	3	2	1	0	1	1	1	3	2	1	2
S	0	0	1	1	2	3	3	2	1	1	1	1	2	2	2	4	3	5	4	2	1	1	2	1
SW	7	7	6	8	9	8	6	7	7	8	9	9	6	5	5	3	5	5	5	9	9	8	9	8
W	2	2	2	1	1	1	2	2	3	5	3	3	4	5	5	6	5	5	7	4	5	6	4	5
NW	2	2	2	3	2	1	3	3	3	0	2	3	3	3	3	3	3	3	1	2	2	2	2	2

TABLE XI.

Wind directions at Chicago, Illinois, July, 1882. In this table 1 = N.; 2 = NE.; 3 = E.; 4 = SE.; 5 = S.; 6 = SW.; 7 = W.; 8 = NW.

Day of month.	Midn't.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
1	8	8	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	3	2	3	3	4	4	4	3	3	2	3	2	2	2	1	1	2
4	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	8	8	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	2	2
6	2	2	2	2	2	2	7	7	7	6	6	6	6	6	6	6	6	5	6	5	5	5	5	5
7	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
8	5	5	5	5	5	5	0	0	6	7	8	8	1	2	1	2	2	2	2	2	2	2	2	2
9	2	2	2	2	2	2	2	2	2	3	5	5	5	5	5	5	5	5	5	5	5	6	6	6
10	6	6	6	7	8	8	8	8	8	8	1	2	6	0	0	0	6	6	6	6	6	6	6	6
11	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6
12	6	6	6	6	7	6	6	6	6	7	6	7	7	7	7	7	7	7	7	7	7	7	7	7
13	7	7	7	7	7	7	7	7	7	7	7	7	3	2	2	2	2	2	1	2	2	2	1	1
14	1	1	1	1	1	1	1	1	1	2	2	2	3	3	3	4	4	4	4	4	4	4	4	4
15	4	4	4	4	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5
16	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	7	6	6	6	6
17	6	6	6	6	6	6	6	6	7	7	1	1	3	3	3	3	3	3	4	4	4	4	4	4
18	4	5	5	5	5	6	6	6	7	7	7	7	7	1	1	3	4	4	7	6	6	6	6	6
19	6	7	7	7	7	7	7	7	7	7	8	8	1	1	1	3	3	3	3	3	2	2	2	2
20	2	2	2	2	8	8	8	7	8	8	8	8	2	2	2	3	3	3	1	3	3	7	7	7
21	7	7	7	7	7	7	7	7	7	7	1	2	3	3	3	3	3	3	3	4	3	1	1	1
22	1	1	1	8	7	7	7	7	7	8	1	1	2	3	4	3	3	3	4	4	4	4	4	4
23	4	4	5	5	5	5	6	6	6	6	6	6	5	4	4	4	3	4	4	4	4	4	4	5
24	5	5	5	6	6	6	6	6	6	6	6	6	6	7	6	6	6	6	6	6	6	6	6	6
25	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	6	5	5	5	5	5
26	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
27	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7
28	7	7	7	7	7	7	7	7	8	8	1	1	1	2	2	2	2	2	2	2	1	1	1	1
29	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
30	2	2	2	2	3	3	3	3	4	3	4	3	3	3	3	3	2	2	2	2	2	2	3	3
31	3	4	4	4	3	4	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3
Summation.																								
N	4	3	4	3	3	4	4	5	4	3	8	6	6	4	5	2	3	2	3	2	3	4	5	4
NE	6	7	7	8	6	5	4	3	4	3	3	5	4	6	5	5	7	7	8	8	8	8	6	7
E	1	0	0	0	2	1	2	3	1	4	2	2	6	7	6	10	7	7	3	4	3	1	2	2
SE	3	3	2	2	0	1	0	0	1	0	1	1	1	3	3	2	2	3	4	4	4	4	4	3
S	5	6	7	5	6	5	3	3	3	3	4	3	4	2	3	3	3	5	3	5	5	5	4	5
SW	7	6	6	6	6	7	9	8	7	6	7	7	7	6	7	7	7	5	7	5	6	7	8	7
W	3	4	4	6	6	6	7	8	8	8	3	4	3	3	2	2	2	2	3	3	2	2	2	3
	2	2	1	1	2	2	2	1	3	4	3	3	0	0	0	0	0	0	0	0	0	0	0	0

TABLE XII.

Wind direction at Chicago, Illinois, August, 1882. In this table 1 = N.; 2 = NE.; 3 = E.; 4 = SE.; 5 = S.; 6 = SW.; 7 = W.; 8 = NW.

Day of month.	Midn't.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
1	3	3	3	3	3	3	3	3	3	3	3	4	4	3	3	3	3	3	3	2	8	2	3	3
2	3	3	3	5	5	5	3	3	3	3	1	2	2	3	3	3	2	2	2	1	2	2	2	2
3	1	1	2	1	1	1	1	1	1	2	2	3	3	3	2	2	2	2	2	2	2	1	1	2
4	2	2	2	2	2	2	2	2	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2
5	2	2	2	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2
6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
7	2	2	2	1	1	1	1	1	1	8	7	7	7	7	7	7	7	7	7	7	8	8	7	7
8	7	7	7	7	7	7	7	7	7	7	7	8	8	1	2	2	2	2	1	1	1	1	8	1
9	8	8	8	8	8	8	8	8	7	7	8	7	8	1	8	8	8	8	8	8	1	8	8	8
10	8	8	8	8	8	8	8	8	8	8	8	8	8	1	2	2	2	3	3	3	3	3	3	3
11	3	3	4	4	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	3	6	6	6
12	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	8	1	2	2	2	2
13	2	2	2	2	3	4	6	6	6	6	6	5	6	6	6	6	6	6	5	5	5	5	5	5
14	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
15	6	6	6	5	6	6	5	5	5	5	6	6	5	4	5	6	6	6	6	6	6	6	6	6
16	6	6	6	5	5	5	5	5	7	8	1	2	1	1	1	1	8	8	1	1	1	1	1	1
17	1	1	1	1	1	1	8	8	8	1	1	1	2	2	2	2	2	1	1	2	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3	3	3	3	3	3
19	3	3	4	4	4	5	5	5	5	5	5	7	7	6	2	3	4	4	4	6	7	6	7	6
20	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6
21	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5
22	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
23	6	6	7	7	6	6	6	6	6	6	6	6	1	2	2	2	2	2	2	2	2	2	2	2
24	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3
25	5	5	5	4	4	4	4	4	4	4	5	4	4	4	4	3	3	4	4	4	4	4	4	4
26	3	3	3	3	3	3	3	2	2	2	2	2	1	1	2	1	1	1	1	1	1	2	2	2
27	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	2
29	2	2	3	2	2	2	2	2	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2
30	3	3	3	3	4	4	4	4	5	4	4	4	5	5	4	4	4	4	4	4	2	2	5	5
31	5	5	5	5	6	6	6	6	6	8	7	7	7	7	8	8	8	8	8	8	8	8	8	8
Summation.																								
N	4	4	3	5	5	5	5	5	4	3	5	2	4	6	2	3	2	3	5	7	6	5	5	4
NE	8	8	8	7	7	6	4	5	4	5	5	7	6	8	13	10	11	9	8	8	9	10	8	10
E	6	6	5	3	2	2	4	3	5	5	4	4	4	4	3	6	4	4	4	3	3	3	4	4
SE	0	0	2	3	3	3	2	2	1	2	1	3	2	2	2	1	2	3	3	2	1	1	1	1
S	4	4	4	5	4	5	5	4	3	2	2	1	2	1	2	1	1	1	2	2	2	2	3	3
SW	5	5	4	3	6	6	6	7	8	7	8	7	6	7	6	7	7	7	5	6	5	5	5	5
W	2	2	3	3	2	2	2	2	4	3	4	5	4	3	1	1	1	1	1	1	1	1	2	2
NW	2	2	2	2	2	2	3	3	2	4	2	2	3	0	2	2	3	3	3	2	4	4	3	2

TABLE XIII.

Wind direction at Chicago, Illinois, September, 1882. In this table 1 = N.; 2 = NE.; 3 = E.; 4 = SE.; 5 = S.; 6 = SW.; 7 = W.; 8 = NW.

Day of month.	Midn't.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
1	8	8	8	8	8	8	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	4	4
2	4	4	4	6	7	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	0	0	6
3	6	6	5	5	5	6	7	7	6	0	5	5	6	6	0	0	0	6	7	7	7	7	7	7
4	7	7	7	8	8	8	8	8	8	8	8	1	1	1	1	1	1	2	2	2	2	2	2	2
5	2	2	2	2	2	2	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6	4	4	4	4	4	4	4	4	4	4	5	5	5	5	0	0	0	6	6	0	0	0	5	6
7	6	6	6	6	6	6	6	6	6	6	6	0	6	6	6	6	6	5	5	5	5	5	5	3
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	2	2
9	2	2	2	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	4	4	3	3	3	3
10	3	3	3	3	8	8	1	1	2	2	2	2	1	2	2	1	1	1	1	8	1	1	1	2
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	2	3	4	4	4	5	5	5	5	5	5	5	5	5	5	4	5	5	4	4	4	5	4	5
13	5	5	5	5	5	5	5	5	5	5	6	6	6	5	8	8	8	7	7	7	7	7	7	6
14	6	5	5	5	6	7	7	7	7	6	6	7	7	7	8	8	7	7	7	7	7	7	7	7
15	8	8	7	7	8	8	8	2	2	3	3	3	4	4	3	3	3	2	2	2	2	3	3	3
16	3	3	3	4	4	4	4	4	5	5	5	5	5	5	4	4	4	4	4	4	3	4	4	5
17	5	5	5	5	5	5	6	6	6	0	0	6	6	0	0	0	0	6	5	6	0	6	0	0
18	0	6	6	6	6	6	6	6	6	0	6	6	6	6	6	6	6	5	5	5	5	5	6	5
19	6	6	6	6	6	6	6	7	7	7	6	6	6	6	6	6	6	6	7	6	6	5	6	7
20	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	1	1	1	1	1	1	1	8
21	8	8	8	8	8	8	8	8	8	8	8	8	1	8	8	8	8	8	8	8	8	8	8	1
22	7	7	7	7	7	7	7	7	0	6	6	6	6	6	7	7	7	7	7	7	6	6	6	6
23	6	6	7	7	7	7	7	7	7	7	8	8	8	8	1	2	2	2	2	2	2	2	2	2
24	2	2	2	1	1	1	1	5	5	5	5	4	4	3	3	2	2	2	2	2	2	2	2	3
25	3	3	4	4	4	4	4	4	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	3
26	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	1	2	1	3
27	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	3	4	4	4	4
28	4	4	4	4	5	5	5	4	4	4	4	5	4	4	4	3	3	3	3	3	3	3	3	3
29	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	3	3	3	3	3	3	3	3
30	3	3	3	3	3	3	3	3	8	8	1	2	2	3	3	2	2	2	2	2	2	2	2	2
Summation.																								
N	0	0	0	1	1	1	4	3	2	2	1	1	3	2	2	3	3	2	3	2	4	3	3	1
NE	6	5	5	3	3	3	2	3	4	3	5	6	7	0	7	9	9	11	10	9	7	7	7	6
E	6	7	5	4	3	3	3	3	3	4	4	4	1	4	5	4	5	4	3	4	0	0	5	9
SE	4	4	0	7	0	5	5	5	4	4	3	2	4	3	3	3	1	1	3	3	2	2	4	2
S	2	3	4	5	4	4	3	4	4	4	5	6	4	3	1	0	2	3	2	2	2	3	1	3
SW	6	5	3	3	5	4	5	4	6	7	8	7	8	8	7	7	5	3	2	3	4	5	6	5
W	3	3	4	3	3	5	4	5	3	2	0	1	1	1	2	2	4	5	6	5	4	3	3	3
NW	3	3	3	4	6	6	4	3	4	4	4	3	2	3	3	2	1	1	1	2	1	1	1	1

TABLE XIV.

Direction of wind at Chicago, Illinois. Number of times winds blew from each of eight points of the compass during each hour of June, July, August, and September, 1882.

Hour.	North.				Northeast.				East.				Southeast.				South.				Southwest.				West.				Northwest.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
Midnight	3	4	4	0	7	6	8	6	4	1	6	6	1	3	0	4	2	5	4	2	6	7	5	6	4	3	2	3	3	2	2	3
1 a. m.	4	3	4	0	5	7	8	5	3	0	6	7	3	3	0	4	2	6	4	3	5	6	5	5	5	4	2	3	3	2	2	3
2 a. m.	3	4	3	0	5	7	8	5	5	0	5	5	2	2	2	2	2	7	4	4	5	6	4	3	5	4	3	4	3	1	2	3
3 a. m.	4	3	5	1	4	8	7	3	5	0	3	4	1	2	3	7	2	5	5	4	3	6	3	3	6	6	3	3	3	1	2	4
4 a. m.	4	3	5	1	5	6	7	3	5	2	2	3	0	2	3	6	3	6	4	4	5	6	3	4	6	6	2	3	3	2	2	6
5 a. m.	5	4	5	1	4	5	6	2	2	1	2	3	1	1	3	5	5	5	5	4	5	7	6	5	5	6	2	3	3	2	2	6
6 a. m.	5	4	5	4	4	4	4	2	3	2	4	3	1	0	2	5	4	3	5	3	5	9	6	6	5	5	2	4	1	2	3	4
7 a. m.	3	5	5	3	5	3	5	4	4	3	3	3	1	0	2	5	4	3	4	4	9	8	7	4	4	5	2	3	2	1	3	3
8 a. m.	4	4	4	2	3	4	4	3	3	1	5	3	3	1	1	4	1	3	3	4	9	7	8	5	6	3	2	4	2	2	3	4
9 a. m.	4	3	3	2	3	3	5	5	4	2	5	4	2	1	2	4	1	3	2	4	8	6	7	6	7	8	4	4	2	2	4	4
10 a. m.	3	5	5	1	4	3	5	5	5	2	4	4	1	1	1	3	2	4	2	0	9	7	8	4	6	8	3	2	2	2	2	4
11 a. m.	2	6	2	1	5	5	7	6	5	2	4	4	2	1	3	2	1	4	2	1	8	7	7	5	7	4	5	4	2	2	2	3
Noon	4	6	4	3	8	4	6	7	4	6	4	1	3	1	2	4	0	4	2	1	7	7	6	8	8	2	3	4	1	2	3	2
1 p. m.	5	4	6	2	8	6	8	4	4	7	4	4	2	3	2	3	0	2	1	3	7	6	7	8	2	2	3	3	1	2	3	3
2 p. m.	2	5	2	2	11	5	13	7	4	7	4	5	2	3	2	3	1	3	2	1	8	7	7	7	2	1	2	2	2	2	2	2
3 p. m.	2	2	3	3	10	5	10	9	10	7	6	5	3	2	1	3	1	3	1	0	8	7	7	7	1	2	2	3	2	2	2	1
4 p. m.	5	3	2	3	7	7	11	9	3	7	4	5	1	2	1	1	2	3	1	2	9	8	7	7	1	1	2	4	2	1	3	1
5 p. m.	5	2	3	2	8	7	9	11	3	7	4	4	1	3	3	1	3	5	1	3	8	5	7	5	1	2	1	5	2	1	3	1
6 p. m.	2	3	5	3	9	8	8	10	3	3	4	3	2	4	3	3	3	5	2	2	6	7	5	3	2	2	3	1	1	0	0	1
7 p. m.	5	2	7	2	5	8	8	9	4	4	3	4	2	4	3	2	2	5	2	2	7	5	6	5	3	2	3	1	3	0	0	2
8 p. m.	4	3	6	4	5	8	9	7	4	3	3	6	3	4	1	2	1	5	2	2	7	6	5	4	3	2	2	1	3	0	0	1
9 p. m.	5	4	5	4	4	8	10	7	5	1	3	6	2	4	1	2	1	5	2	3	8	7	5	3	0	2	2	3	3	0	0	1
10 p. m.	3	5	5	3	7	6	8	7	4	2	4	5	1	4	1	4	1	4	3	1	9	8	5	5	3	2	2	3	2	0	0	1
11 p. m.	3	4	4	1	6	7	10	6	4	2	4	9	1	3	1	2	1	5	3	3	9	7	5	5	3	3	2	3	3	2	0	1

TABLE XV.

Summation of the four months.

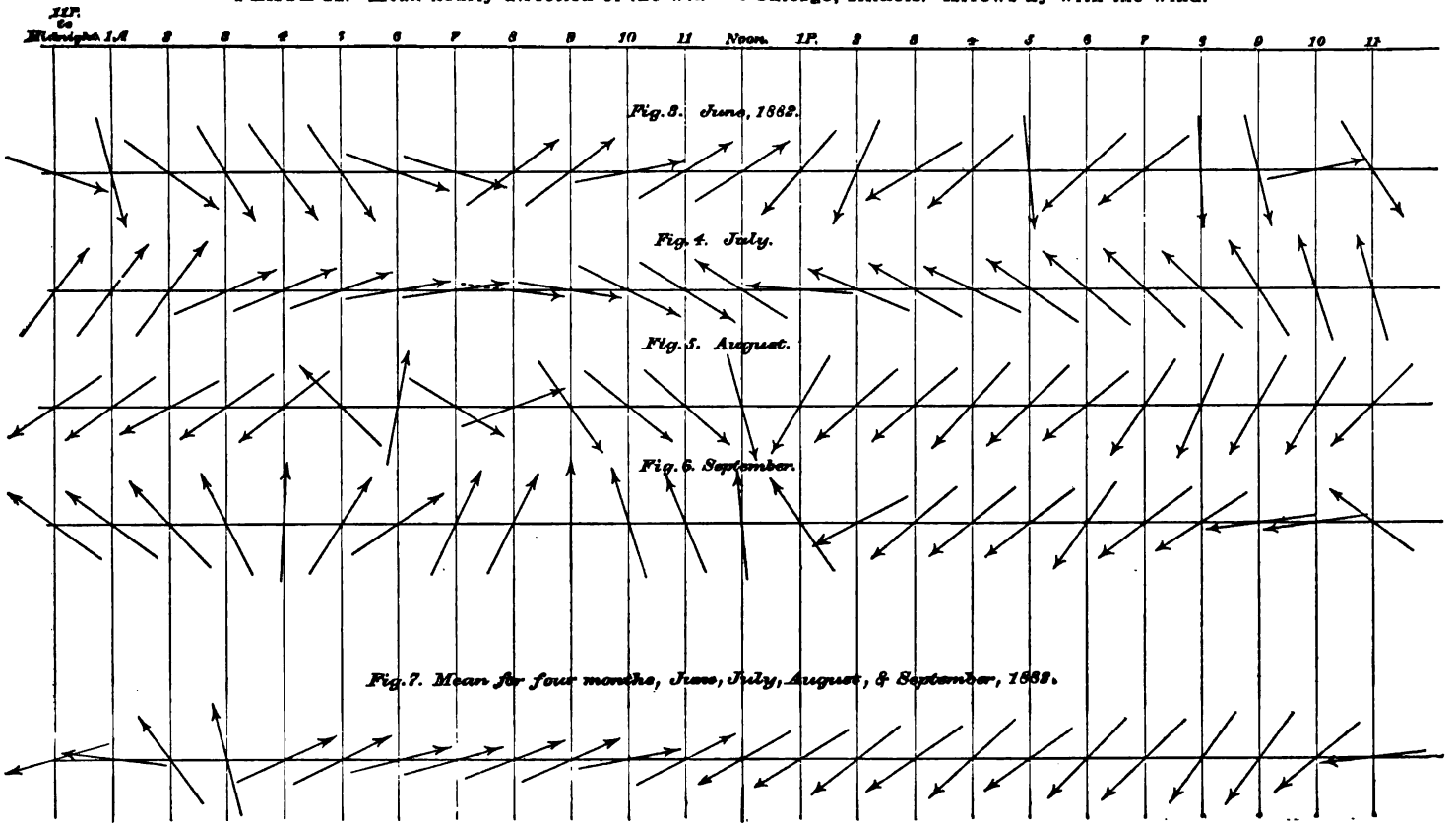
Hour.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
Midnight	11	27	17	8	13	24	12	10
1 a. m	11	25	16	10	15	21	14	10
2 a. m	10	25	15	12	17	18	16	9
3 a. m	13	22	12	13	19	15	18	10
4 a. m	13	21	12	9	17	21	16	13
5 a. m	15	18	8	10	19	23	16	13
6 a. m	18	14	12	8	15	25	20	10
7 a. m	16	16	13	8	13	28	19	9
8 a. m	14	15	12	9	11	30	20	11
9 a. m	12	14	17	8	10	28	19	14
10 a. m	17	17	15	6	13	32	11	11
11 a. m	11	23	15	8	11	29	15	10
Noon	17	25	15	10	10	28	10	7
1 p. m	17	28	19	10	6	28	9	5
2 p. m	11	36	18	10	7	26	7	7
3 p. m	10	34	22	9	5	29	6	7
4 p. m	13	34	19	6	8	28	8	6
5 p. m	12	35	18	8	12	23	9	5
6 p. m	13	35	13	12	10	20	12	7
7 p. m	10	30	15	11	11	21	11	7
8 p. m	17	29	10	10	10	22	10	8
9 p. m	17	29	15	9	11	25	11	5
10 p. m	16	28	15	10	9	28	10	6
11 p. m	12	29	19	7	12	26	11	6

TABLE XVI.

Mean hourly direction of the wind at Chicago, Illinois, as computed from Lambert's formula.

Hour.	June, 1882.	July, 1882.	August, 1882.	September, 1882.	Mean of four months.
	° ′	° ′	° ′	° ′	° ′
Midnight	n. 12 43 w.	s. 39 48 w.	n. 53 20 e.	s. 53 52 e.	n. 75 15 e.
1 a. m	n. 45 00 w.	s. 40 55 w.	n. 53 20 e.	s. 51 47 e.	s. 75 58 e.
2 a. m	n. 22 23 w.	s. 40 55 w.	n. 69 27 e.	s. 43 45 e.	s. 55 27 e.
3 a. m	n. 38 59 w.	s. 71 34 w.	n. 59 2 e.	s. 20 56 e.	s. 18 58 e.
4 a. m	n. 34 7 w.	s. 73 30 w.	n. 54 28 e.	s. 10 42 w.	s. 80 0 w.
5 a. m	n. 82 11 w.	s. 76 32 w.	s. 45 00 e.	s. 29 35 w.	s. 68 29 w.
6 a. m	n. 86 21 w.	s. 83 40 w.	s. 8 8 w.	s. 53 8 w.	s. 78 49 w.
7 a. m	s. 72 33 w.	s. 85 2 w.	n. 74 45 w.	s. 22 45 w.	s. 72 28 w.
8 a. m	s. 70 57 w.	n. 88 22 w.	s. 66 15 w.	s. 22 23 w.	s. 72 47 w.
9 a. m	s. 84 48 w.	n. 85 30 w.	n. 38 40 w.	s. 9 29 w.	s. 77 3 w.
10 a. m	s. 60 39 w.	n. 63 26 w.	n. 60 15 w.	s. 12 32 e.	s. 72 50 w.
11 a. m	s. 62 21 w.	n. 58 00 w.	n. 45 00 w.	s. 17 45 e.	s. 63 50 w.
Noon	n. 40 22 e.	s. 63 26 e.	n. 14 32 w.	s. 12 44 e.	n. 60 45 e.
1 p. m	n. 25 21 e.	s. 89 4 e.	n. 35 47 e.	s. 33 41 e.	n. 60 57 e.
2 p. m	n. 50 43 e.	s. 72 18 e.	n. 54 37 e.	n. 71 34 e.	n. 66 13 e.
3 p. m	n. 45 00 e.	s. 64 35 e.	n. 53 8 e.	n. 47 56 e.	n. 71 14 e.
4 p. m	n. 2 29 w.	s. 77 40 e.	n. 48 35 e.	n. 45 00 e.	n. 58 49 e.
5 p. m	n. 45 00 e.	s. 66 29 e.	n. 52 18 e.	n. 45 00 e.	n. 71 55 e.
6 p. m	n. 53 8 e.	s. 59 2 e.	n. 45 00 e.	n. 37 44 e.	n. 56 13 e.
7 p. m	n. 2 29 w.	s. 57 54 e.	n. 27 59 e.	n. 48 6 e.	n. 57 13 e.
8 p. m	n. 14 2 w.	s. 50 48 e.	n. 16 53 e.	n. 54 41 e.	n. 49 45 e.
9 p. m	s. 81 52 w.	s. 38 53 e.	n. 21 34 e.	n. 82 11 e.	n. 58 16 e.
10 p. m	n. 40 14 w.	s. 23 38 e.	n. 26 9 e.	n. 82 52 e.	n. 61 42 e.
11 p. m	n. 62 32 w.	s. 19 32 e.	n. 42 43 e.	s. 74 53 e.	n. 82 37 e.

PLATE II.—Mean hourly direction of the wind at Chicago, Illinois. Arrows fly with the wind.



CONCLUSIONS.

1st. The wind velocity at the lake crib is double that at Chicago from 11 p. m. to 6 a. m. This difference is gradually diminished until noon, when the velocity at the lake crib is only about a third greater than at Chicago.

2d. During the months from April to September the mean wind velocity at the lake crib is about 1.6 greater than at Chicago; more exactly, a wind of 25 miles per hour at the lake crib would be only 16 miles per hour at Chicago.

3d. The diurnal range of the wind velocity at the lake crib is about half that at Chicago; this may be partially accounted for from the fact of a clearly defined land and lake breeze, and the less heating of the atmosphere over the lake.

4th. E. and SE. and S. and SW. winds give more of an equality between the velocity at Chicago and that at the lake crib, this may also be accounted for as in (3) above.

H. A. HAZEN,
Computer, O. C. S. O.

ADDENDUM.

The following notes relating to the anemometers and their exposures were received too late to be included in the body of this report, and are added here. The anemometers were compared side by side for ten days in February, 1883; the total number of miles recorded were 1,893 for lake crib and 1,895 for Chicago, showing that the results of both instruments are comparable. Lake crib is a pentagonal structure, about ninety-eight feet across, with its deck nineteen feet above water-line; its distance from the Chicago office is 16,500 feet in an ENE. direction.

The anemometer at the crib was exposed six feet above the roof of the keeper's house and thirty-seven feet above the lake surface; its height above the ground at office site, corner of La Salle and Madison streets, was twenty-five feet.

The Chicago station anemometer receives unobstructed wind-force from the south around to the north by the west, except as influenced by the irregularities due to the presence of buildings, which, though not as high as the anemometer, yet must retard the velocity. On the north, some 550 feet, is the county building, with a roof about twelve feet above the anemometer. The only other roof within a radius of a mile, as high as the anemometer, is that of the Montauk building, one-fourth mile due SE. The anemometer cups are 103 feet above ground, and consequently seventy-eight feet above the position of the crib cups.

August 10th, 1883. H. A. HAZEN.

UNITED STATES OF AMERICA:
WAR DEPARTMENT.

SIGNAL SERVICE NOTES
No. VII.

VARIATION OF RAINFALL

WEST OF THE MISSISSIPPI RIVER.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY,

BY

H. A. HAZEN,
COMPUTER, OFFICE OF THE CHIEF SIGNAL OFFICER.

BY AUTHORITY OF THE SECRETARY OF WAR.

WASHINGTON:
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WASHINGTON:
OFFICE OF THE CHIEF SIGNAL OFFICER.
1883.

1884, No. 12.

Gift of

U. S. Geol. Survey

THE SECULAR VARIATION OF RAINFALL IN THE REGION WEST OF THE MISSISSIPPI RIVER.

The following investigation is the outcome of a suggestion from Mr. Jay Gould, through Professor Baird of the Smithsonian Institution, that the building of railways in Texas and the southwest has increased the rainfall in that region:

The Chief Signal Officer has desired that the question be examined for the whole country, west of the Mississippi river and not merely for the southwest.

It is proposed, in this paper, to collect all the material available, in order to determine, if possible, the character of this secular variation.

The materials for the discussion are: 1st, Signal Service observations from a few stations; 2d, Reports from voluntary observers; 3d, Reports from Army post surgeons; and 4th, Reports from the Pacific railways.

All the observations for twelve years, from 1871 to 1882, have been tabulated; those previous to 1874 were taken from Mr. Schott's collection; the remainder mostly from manuscript records in the office of the Chief Signal Officer.

All yearly records, made up from less than twelve months' observations, are marked with an *. In case it has been necessary to interpolate a whole year's record, it has been done, in general, by first mapping all the observations for any year and then interpolating a station from its neighbors; all such interpolated values are bracketed.

In many instances observations have been found for the same year, at the same station, from different observers, differing by ten inches. These discrepancies are due mostly to manner of exposure and the great uncertainty arising from the measurement of the depth of snow.

It will be seen that the stations are by no means near enough to give the best results, yet we may make a partial comparison between the mean annual rainfall for various districts.

For the purpose of such comparison the stations have been grouped in seven districts. Of these, numbers S. I., S. II., and S. III., lie, in general, to the south of the parallel of 38°. No. S. I. between 88° and 96°; longitude west of Greenwich. No. S. II. from 96° to 104°; and No. S. III. from 104° to 112°. Numbers N. I., N. II., N. III., and N. IV, lie to the north of 38°, and the first three between the same meridians as those above. N. IV. lies to the west of 112°.

There are in S. I., ten stations, S. II., seventeen, and S. III., seven; in N. I., there are eight stations; in N. II., seven; in N. III., five; and in N. IV., seventeen.

Tables I. and II. show these stations, together with the rainfall for each year from 1871 to 1882. Tables III. and IV. give the mean annual rainfall for each one of the seven districts and the 3d order of means.

Figure 1. Is a graphical representation of the annual mean values of Table III; the curve S. I. has been drawn to the scale on the left-hand side, the values used being fifteen inches less than those in the Table; the curve S. III. has been drawn to the same scale, the values in the table being first increased by ten inches.

Figure 2. Contains curves for the 3d order of means; the curve S. I. has been drawn to scale, the values used being fifteen inches less than those in Table III;

S. III. has been drawn to the same scale after increasing the tabular values by fifteen inches.

Figures 3 and 4 are projected from the annual means and from the 3d order of means, respectively, as found in Table IV.

Examining these figures we find: 1st, In all the districts except N. IV., a very great deficiency in the amount of rainfall about the year 1879.

2d. A remarkable uniformity in the secular variations in the districts north of the 38th parallel, when compared with those south of it, *e. g.* N. I. and S. I., N. II. and S. II., N. IV., taking in California and the Pacific coast, has an annual fluctuation peculiar to itself.

3d. The districts N. I. and S. I. to the east have the maximum and the minimum points about one year earlier than N. II. and S. II., immediately to the west.

4th. All the districts except N. IV., show a gradual increase in annual rainfall during the past three years.

It should be noted than many more years of observation will be needed, as well as many additional stations, together with greater care at the northern stations in measuring snow, before any secular variation can be fully established. We may conclude from this discussion:

1st. The northern and southern parts of the United States under discussion have mostly the same fluctuations in annual rainfall.

2d. The gradual increase in rainfall during the past three years is noticeable over a large extent of country and not merely in a particular section.

TABLE I.—*Annual rainfall west of the Mississippi river, distributed in three districts.*

	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	
Cairo, Illinois	[29.0]	25.5	50.9	48.2	52.9	55.6	39.5	41.8	45.4	49.6	32.2	61.6	
Leavenworth, Kansas	[49.0]	47.0	33.0	32.0	31.3	44.5	52.1	35.2	41.6	35.9	40.0	28.0	
Fort Gibson, Indian Territory	[40.0]	[35.0]	39.3	38.9	44.1	31.5	46.8	13.1	33.1	30.5	37.8	38.0*	
Memphis, Tennessee	[59.0]	44.0	56.2	44.1	57.0	55.5	73.5	49.3	52.3	61.7	42.8	71.0	
Shreveport, Louisiana	[55.0]	51.0	52.4	54.8	51.0	54.5	47.7	55.8	32.0	66.6	53.7	65.1	} S. I., from 88° to 96°.
Vicksburg, Mississippi	[60.0]	58.3	41.2	66.0	70.0	51.7	53.0	60.8	52.3	84.2	51.7	71.6	
Fayette, Mississippi	[53.0]	[50.0]	[42.0]	44.0	65.8	56.4	72.2	58.5	54.4	72.0	55.4	[68.0]	
Brookhaven, Mississippi	68.6	57.9	58.9	53.0	73.9	53.4	69.3	03.8	62.0	[75.0]	[66.0]	[70.0]	
New Orleans, Louisiana	64.5	64.0	70.0	61.0	85.5	67.2	63.1	60.2	51.3	69.8	64.0	50.2	
Galveston, Texas	[42.0]	41.7	58.9	49.6	58.5	50.9	66.9	60.9	26.9	51.0	53.3	57.7	
Mean	52.0	47.5	50.3	49.2	59.0	52.1	58.4	50.5	45.2	59.7	49.7	57.9	
Dodge City, Kansas	[20.0]	[23.0]	[25.0]	[20.0]	10.7	15.4	27.9	18.0	15.4	18.1	33.6	14.0*	
Fort Sill, Indian Territory	[30.0]	[35.0]	[32.0]	[30.0]	[33.0]	[26.0]	[35.0]	33.7	25.1	33.8	28.2	31.1	
Denison, Texas	[35.0]	[35.0]	[40.0]	[35.0]	[38.0]	42.1	52.6	41.2	20.4	46.3	37.0	50.4	
Melissa, Texas	[35.0]	[37.0]	[40.0]	29.8	38.8	42.2	75.8	45.3	32.2	45.0	[35.0]	[52.0]	
Fort Griffin, Texas	16.4	20.6	12.0	26.3	[28.0]	[32.0]	[40.0]	29.8	18.9	28.7	20.9	[40.0]	
Stockton, Texas	5.2	12.0	11.2	12.0	16.8	12.4	15.2	12.5	5.1	33.4	12.6	25.6	
Austin, Texas	30.1	33.2	43.4	42.0	30.8	32.6	41.8	21.6	19.4	41.5	25.3	[35.0]	} S. II., from 96° to 104°.
Fredericksburg, Texas	[32.0]	[34.0]	[40.0]	[34.0]	[30.0]	[33.0]	[41.0]	22.8	18.3	47.2	24.8	33.5	
San Antonio, Texas	33.1	23.7	28.9	[35.0]	30.0	[34.0]	[43.0]	39.5	22.8	41.9	23.8	30.4	
Eagle Pass, Texas	[28.0]	[22.0]	[20.0]	[21.0]	[25.0]	[29.0]	[30.0]	25.7	18.6	31.9	28.0	22.7	
New Ulm, Texas	[60.0]	[55.0]	88.0	58.0	63.3	44.4	59.3	50.4	35.4	68.4	54.0	73.9	
Indianola, Texas	[40.0]	[40.0]	43.3	44.1	35.4	32.6	42.7	41.7	20.8	45.2	37.7	41.9	
Laredo, Texas	9.9	18.4	18.7	21.8	[28.0]	[22.0]	21.4	27.5	21.5	20.7	25.0	23.0*	
Brownsville, Texas	20.4	22.4	27.6	26.8	[29.0]	[27.0]	25.9	30.4	34.8	38.1	31.7	32.6	
Mean	28.2	29.4	33.6	31.1	31.2	30.3	39.4	31.8	22.5	39.0	30.0	36.6	
Fort Wingate, New Mexico	21.6	20.8	25.1	7.6	10.0	10.4	8.3	12.1	8.1	11.1	15.2	12.9	
Santa Fé, New Mexico	14.6	9.0	9.0	19.8	19.0	15.1	13.2	19.6	11.4	9.9	21.8	11.4	
Fort Verde, Arizona	4.8	13.1	8.4	17.3	[10.0]	[11.0]	10.6	10.6	9.0	7.2	15.4	11.9	
Fort Apache, Arizona	4.9	20.0	8.1	16.8	[12.0]	[15.0]	[9.0]	[13.0]	18.6	14.8	31.1	27.6	} S. III., from 104° to 112°.
Fort Grant, Arizona	17.6	14.7	18.0	17.8	[12.0]	[14.0]	[10.0]	[11.0]	12.8	15.4	19.0	14.8	
El Paso, Texas	7.6	6.8	5.7	7.2	[9.0]	[9.0]	9.0	[8.0]	6.6	14.4	18.2	8.3	
Fort Whipple, Arizona	13.6	16.7	13.5	26.8	10.0	11.7	9.4	15.2	12.0	8.8	[15.0]	[9.0]	
Mean	12.1	14.4	12.5	16.2	11.7	12.3	9.9	12.8	11.2	11.7	19.4	13.7	

TABLE II.—*Annual rainfall west of the Mississippi river, distributed in four districts.*

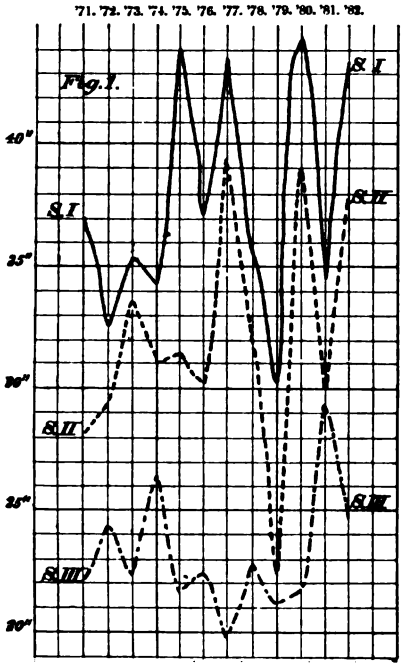
	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	
Boonesboro', Iowa	[20.0]	32.2	28.0	34.4	[32.0]	36.0*	50.6	38.7	31.5	28.6	[34.0]	[33.0]	
Davenport, Iowa	26.0*	36.4	28.1	36.8	32.0	46.8	35.1	31.2	33.9	42.7	37.3	36.6	
Dubuque, Iowa	34.3	[36.0]	[29.0]	30.1	35.5	50.3	39.0	38.3	32.4	40.3	55.2	32.8	
Independence, Iowa	25.6	30.0	29.2	31.9	34.5	51.9	34.3	30.1	35.3	42.9	43.2	31.0	
Keokuk, Iowa	[45.0]	29.4	42.0	35.4	48.4	51.6	47.5	31.8	22.5	34.5	39.0	41.5	N. I., from 88° to 96°.
Duluth, Minnesota	29.1	29.9	38.7	36.4	26.9	32.3	34.3	28.1	45.3	38.1	37.6	38.0	
Minneapolis, Minnesota	32.3	27.4	35.9	44.9	30.0	[31.0]	25.2	22.2	25.0	22.2	34.7	23.0	
Saint Paul, Minnesota	29.4	29.2	33.7	35.5	30.7	23.7	28.8	22.8	32.4	29.8	39.2	23.1	
Mean	30.2	31.3	31.8	35.7	33.8	40.8	36.8	30.4	32.8	34.8	40.0	32.4	
Fort Sully, Dakota	15.7	18.1	13.1	16.0	14.0	20.4	19.1	20.2	23.5	16.7	16.5	12.0	
Fort Totten, Dakota	17.0	19.0	17.3	16.7	22.2	14.4	17.8	22.4	19.2	22.2	13.6	18.6	
Pembina, Dakota	[18.0]	17.3	13.0	12.2	14.6	25.8	21.7	33.8	19.3	29.3	15.5	22.5	
Yankton, Dakota	[20.0]	[19.0]	24.0	23.8	37.2	28.8	28.1	28.7	22.8	21.7	41.0	20.6	N. II., from 96° to 104°
Breckenridge, Minnesota	[24.0]	[24.0]	27.4	27.6	17.8	18.1	29.4	35.7	19.8	[21.0]	[38.0]	[18.0]	
De Soto, Nebraska	37.1	34.4	20.1	25.8	38.6	35.5	33.3	32.4	16.4	23.0	34.9	26.0	
Omaha, Nebraska	22.8	36.2	24.2	25.8	42.9	32.5	41.0	37.0	30.3	28.5	45.7	37.7	
Mean	22.1	24.0	20.0	21.1	26.8	25.1	27.2	30.0	21.6	23.2	29.3	22.2	
Denver, Colorado	12.4	18.4	11.4	12.5	20.3	20.1	16.4	15.5	10.9	9.6	12.8	14.5	
Pike's Peak, Colorado	[35.0]	[48.0]	[22.0]	26.9	24.7	23.9	25.6	43.3	39.8	40.6	44.6	28.8	
Virginia City, Montana	[10.0]	9.8	[18.0]	16.3	17.5	17.6	17.5	19.1	17.8	[21.0]	[30.0]	[25.0]	N. III., from 104° to 112°.
Salt Lake City, Utah	[22.0]	[17.0]	33.0	20.4	23.6	21.3	16.4	19.8	13.1	10.9	16.9	16.0	
Cheyenne, Wyoming	[9.0]	13.8	10.0	9.7	12.1	5.0	11.7	12.6	7.3	8.4	11.9	8.6	
Mean	17.7	19.4	18.9	17.2	19.6	17.6	17.5	22.1	17.8	18.1	23.2	18.6	
Benecia Barracks, California	16.2	10.8	9.1	13.9	14.9	15.4	7.1	21.2	17.7	21.0	14.7	14.2	
Yuma, California	0.6	2.7	3.1	7.6	0.8	0.6	1.8	2.4	1.7	0.7	1.0	1.8	
San José, California	21.0	17.1	12.6	12.5	5.5	12.7	6.6	17.1	12.2	[11.0]	16.0	14.0	
San Diego, California	5.1	6.2	13.0	11.1	6.8	7.2	8.1	13.9	14.8	10.4	5.0	9.7	
San Francisco, California	20.7	33.2	31.2	19.2	19.4	17.2	11.9	33.3	30.8	30.1	23.7	17.7	
Boise City, Idaho	25.8	17.9	17.7	15.0	[20.0]	[19.0]	[15.0]	10.2	17.6	10.7	13.6	14.4	
Eola, Oregon	40.9	37.9	35.6	37.0	42.7	42.3	50.2	39.5	50.3	38.5	35.0*	44.5	
Portland, Oregon	49.9	46.9	49.8	46.2	60.1	55.0	58.3	47.7	62.2	51.9	58.0	67.2	
Red Bluff, Oregon	[24.0]	33.6	13.1	17.8	13.3	22.7	17.9	49.2	32.1	27.8	24.9	21.8	N. IV., west of 112°.
Suisun, California	[24.0]	19.2	17.1	18.8	15.6	14.6	9.3	26.7	26.2	22.0	21.1	14.4	
Stockton, California	16.7	13.8	10.8	15.2	14.8	12.5	7.0	16.7	15.0	20.1	9.9	11.1	
Auburn, California	33.9	35.2	27.0	33.2	34.0	31.8	18.1	35.0	45.2	41.8	35.5	24.1	
Livermore, California	17.9	11.5	11.2	10.8	16.5	12.5	6.9	15.1	13.2	20.6	10.9	12.6	
Marysville, California	13.5	13.7	23.6	17.6	13.6	16.1	11.2	22.4	20.9	18.4	16.5	13.4	
Sacramento, California	18.8	18.0	18.2	18.0	23.0	18.1	8.6	20.7	21.4	32.0	20.7	18.1	
Modesto, California	7.9	10.5	8.0	14.1	9.0	7.5	5.2	10.3	13.0	11.2	6.0	8.4	
Truckee, Nevada	35.9	32.5	37.1	37.3	27.4	30.3	16.4	26.0	30.7	[28.0]	14.4	28.8	
Mean	21.9	21.2	19.9	20.3	19.8	19.7	15.3	24.0	25.0	23.3	19.2	19.8	

TABLE III.—*Mean annual rainfall and 3d order of means.*

	S. I.	1st.	2d.	3d.	S. II.	1st.	2d.	3d.	S. III.	1st.	2d.	3d.
1871	52.0				28.2				12.1			
1872	47.5	49.7			29.4	28.8			14.4	13.2		
1873	50.3	48.9	49.3		33.6	31.5	30.2		12.5	13.4	13.3	
1874	49.2	49.8	49.4	49.3	31.1	32.4	32.0	31.1	16.2	13.9	13.9	13.6
1875	59.0	54.1	52.0	50.7	31.2	31.2	31.8	31.9	11.7	14.4	14.2	14.0
1876	52.1	55.6	54.8	53.4	31.2	30.8	31.0	31.4	12.3	14.0	13.0	13.6
1877	58.4	55.2	55.4	55.1	30.3	34.8	32.8	31.9	9.9	12.0	11.6	12.3
1878	50.5	54.4	54.8	55.1	39.4	35.6	35.2	34.0	12.8	11.1	11.2	11.4
1879	45.2	47.8	51.1	53.0	31.8	27.2	31.4	33.3	11.2	11.4	11.7	11.4
1880	59.7	52.4	50.1	50.6	22.5	25.8	26.5	29.0	11.7	12.0	11.7	11.7
1881	49.7	54.7	53.6	51.8	39.0	34.5	30.2	28.4	19.4	11.4	11.7	12.6
1882	57.9	53.8	54.2	53.9	30.0	33.3	33.9	32.0	13.7	15.6	13.5	14.8
					36.6					16.5	16.1	

Graphic representation of mean annual rainfall.

Actual means.



3d order of means.

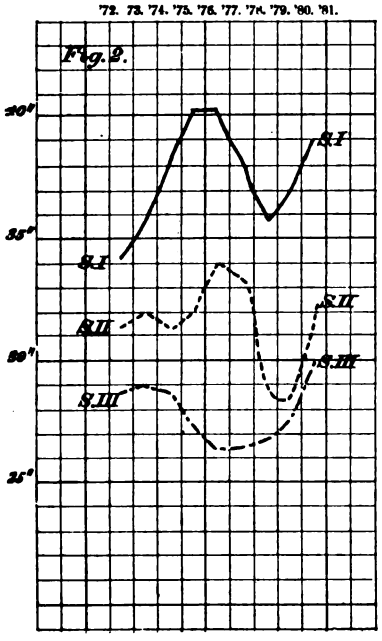
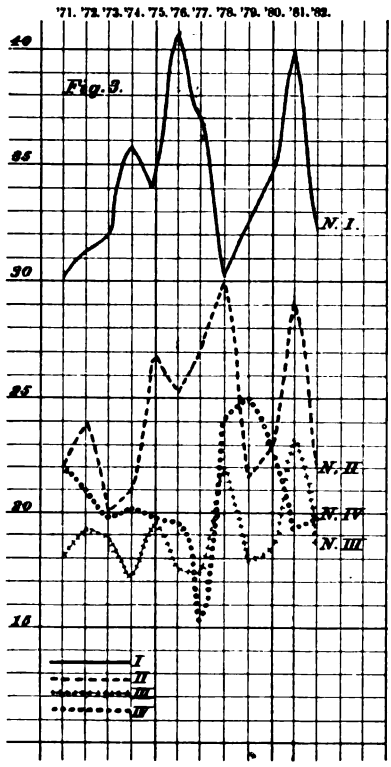


TABLE IV.—*Mean annual rainfall for districts N. I., N. II., N. III., and N. IV., with 3d order of means. All districts north of* 38°.

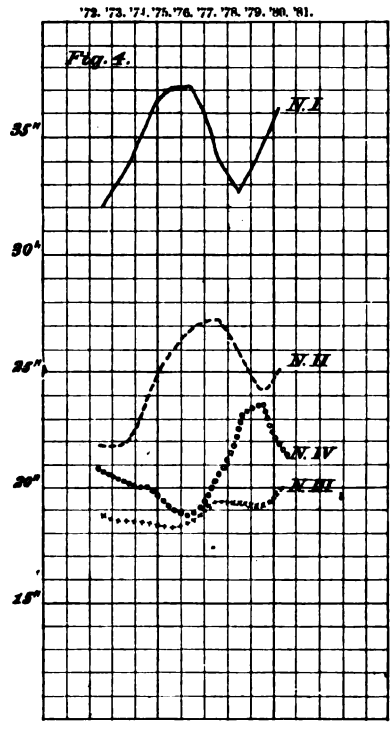
	N. I.	1st.	2d.	3d.	N. II.	1st.	2d,	3d.	N. III.	1st.	2d.	3d.	N. IV.	1st.	2d.	3d.
1871..	30.2				22.1				17.7				21.9			
1872..	31.3	30.8	31.2		24.0	23.0	22.5		19.4	18.6	18.9		21.2	21.6	21.1	
1873..	31.8	31.6	32.7	32.0	20.0	22.0	21.3	21.9	18.9	19.2	18.6	18.8	19.9	20.6	20.4	20.8
1874..	35.7	33.8	34.3	33.5	21.1	20.6	22.3	21.8	17.2	18.0	18.2	18.4	20.3	20.1	20.0	20.2
1875..	33.8	34.8	36.0	35.2	26.8	24.0	25.0	23.6	19.6	18.4	18.5	18.4	19.8	20.0	19.9	20.0
1870..	40.8	37.3	38.0	37.0	25.1	25.0	26.1	25.6	17.6	18.6	18.1	18.3	19.7	19.8	18.6	19.2
1877..	36.8	38.8	36.2	37.1	27.2	25.2	27.4	26.8	17.6	17.6	18.7	18.4	15.3	17.5	18.6	18.6
1878..	30.4	33.6	32.6	34.4	30.0	28.6	27.2	27.3	17.5	19.8	19.9	19.3	24.0	19.6	22.0	20.3
1879..	32.8	31.6	32.7	32.6	21.6	25.8	27.2	25.6	22.1	20.0	19.0	19.4	25.0	24.5	24.4	23.2
1880..	34.8	33.8	35.6	34.2	23.2	22.4	24.1	24.2	17.8	18.0	19.3	19.2	23.3	24.2	22.7	23.6
1881..	40.0	37.4	36.8	36.2	29.3	26.2	24.3	25.2	18.1	20.6	20.8	20.0	19.2	21.2	20.4	21.6
1882..	32.4	36.2			22.2	25.8	26.0		23.2	20.9			19.8	19.5		
									18.6							

Graphical representation of the above figures.

Actual means.



3d order of means.



Met. 8

UNITED STATES OF AMERICA:
WAR DEPARTMENT.

SIGNAL SERVICE NOTES

No. VIII.

THE STUDY OF METEOROLOGY

IN THE HIGHER SCHOOLS OF

GERMANY, SWITZERLAND, AND AUSTRIA.

PREPARED UNDER THE DIRECTION OF

BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,

CHIEF SIGNAL OFFICER OF THE ARMY,

BY

FRANK WALDO,

COMPUTER, OFFICE OF THE CHIEF SIGNAL OFFICER.

BY AUTHORITY OF THE SECRETARY OF WAR

WASHINGTON:
OFFICE OF THE CHIEF SIGNAL OFFICER
1883.

UNITED STATES OF AMERICA:
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THE STUDY OF METEOROLOGY IN THE HIGHER SCHOOLS OF GERMANY, SWITZERLAND, AND AUSTRIA.

I.

There has as yet appeared no statement concerning the extent to which meteorology is studied in various institutions of learning, and it is hoped that this contribution to the subject will be of interest to meteorologists and scientific educators.

On making personal inquiries of some German meteorologists it was learned that the general opinion is, that the study of meteorology is too much neglected, and that any statistics that might be collected would only strengthen this view. In consideration of this fact, it was an agreeable surprise to find that in some institutions meteorology is not only taught in connection with geography, but also as a science in itself, and that there are evidences that, before many years, it will rank with the other natural sciences. Some of the teachers are themselves original workers, and this cannot fail to inspire with enthusiasm the students who come in contact with them.

Those who are acquainted with the methods of studying physical science in general in America, know that most of the training received by younger men who desire to enter the profession, consists of what we may call a "picked up" knowledge; not "picked up" in the sense that it is done in a careless way, but that the young man himself must carry out alone his courses of study, and must get what information he can from older assistants, who have, in their turn, had to go through the same necessarily irregular course. One cannot learn much of a science while one is engaged upon routine work in which he is only a single factor, and yet, in this way, is obtained all the "professional training" that a young assistant receives in that part of his work by which he earns his bread and butter. The older scientists all realize this lack of opportunity for young men, and most of them are willing to give all the aid in their power to a student's desire for advancement in his profession. They know that this is the way to keep up a line of investigators, and that unless they pursue this course, the progress of the science must be checked. It is a matter of considerable import when a scientist, perhaps at the head of his profession, will give a young man two or three hours a week of his valuable time without any recompense, except the satisfaction of knowing that the student is working hard. This same scientist would ask one or two hundred dollars for a single hour of lecture before the public, or perhaps he would say he had no time to lecture even if offered more than that sum.

I have never seen this matter brought to notice, and do not think it is generally known. Only those scientists who have given, and those students who have received, know the great amount of good done by a custom which has, I suppose, been handed down for generations. What is true of this practice in our own country is also true, to a great extent, in Germany.

So much for the study of science in general; but how about meteorology in particular? Will the same thing take place in the study of this science in America? Probably not. We have a few men only who have made this subject enough of a study to be able to give instruction to younger men. We have not more than two or three

schools where there is any pretence of teaching meteorology, and even then the instruction is of a very elementary nature. The time is coming when this will not be true. Many new state meteorological services are coming into existence, and even the Signal Service itself needs more workers who are acquainted with what has been done and what ought to be done. Who are to fill these positions? The time is past when a well-trained young mathematician or physicist can devote a year to reading the works of others in meteorology, and then have a good idea of the subject. He must study and think, and not merely receive. With one exception, the English language is entirely wanting in writers on *theoretical dynamical meteorology*, as it must be studied by a young man making it his profession, and we can congratulate ourselves that this author is an American. From what can be judged from a distance, the English are as poorly off as Americans in regard to instruction in meteorology. The present paper, however, shows that in Germany probably more attention is paid to this study than in any other country, and the prospects are that the instruction will increase rather than diminish.

One great drawback to a systematic study of meteorology at present is a proper text-book in German. Schmid's Meteorology, published in 1860, is perhaps the best up to that date, but in many respects it is far behind the present time. The professors in the schools must spend much time in sifting the substance for their lectures from the older text books and from single writings of meteorologists. The "Oesterreichischen Zeitschrift für Meteorologie" is of the greatest assistance in this, and, in fact, it is almost indispensable. The revolution which meteorology has undergone in Germany, and which has antiquated much of Dove's work, has undoubtedly had a great effect on the study of the science in the universities. The great change in the matter taught, from the calm acceptance of the generalizations deduced by the older meteorologists from a multitude of observations, to the study of more theoretical considerations, based on dynamical and physical principles which have been carefully studied by the younger German meteorologists, has made it appear that meteorology has a brighter future before it. Numerous short papers in the meteorological journal above referred to, show how keenly the young instructors are watching the growth of the science in the hands of the professional meteorologists. Short reviews of papers which must have taken much time to read, and which show that the reading has been carefully done, are frequent. Reports upon casual phenomena also show that study is not limited to pure theory alone.

That there are no chairs of meteorology in German universities is much to be regretted, (in Vienna alone is the professor's work purely meteorological,) because until these are established there cannot be that building up of a particular school of students which will make itself especially felt. A man is needed to exercise the same influence in meteorology that Neumann, of Königsberg, exerted on the students of physics. This is particularly true of the theory and the use of meteorological instruments which subjects are very much neglected.

It is impossible to obtain an exact idea of the extent to which the different branches of meteorology are lectured upon, because of the latitude allowed the lecturer in the German universities. The only way to get this knowledge would be by hearing the lectures, because we do not have a definite idea of what a particular topic will include, as we have in mathematics, physics, or chemistry. There is, however, undoubtedly a great diversity of subjects in the various institutions. For instance, we can expect that in Halle the lectures will partake of the nature of Overbeck's memoir, in the Annalen der Physik und Chemie, July, 1882, while in Berlin we should expect Thiesen to devote much time to instruments.

In Christiania, Norway, Professor Mohn is professor of meteorology in the university, and his lectures cover the ground of his (Grundzüge) Principles of Meteor-

ology. Although this book is perhaps the best of its kind, yet it does not introduce mathematical methods, and in that respect there is wanting that training which is necessary to make a theoretical investigator. It is believed that Professor Guldberg gives no mathematical meteorological lectures in this university, although he is so eminently fitted for the work.

I think there is no German meteorological institution, outside of the Deutsche Seewarte, at Hamburg, where there is regular instruction given, but it would be well to follow the example of this institution in America. Here there is a course of lectures on navigation, mathematics, physics, and meteorology; the instructors are assistants in the Seewarte, and the hearers are candidates for teachers' positions in the naval schools. The instruction for the season, which extends from April 1st to September 30th, is furnished by the state free of charge to the students. In the last two years ten men have received instruction. Professor Dr. G. Neumayer has prepared a letter from which the following details, in regard to this course of instruction, have been taken:

"Those branches of navigation are taught which require a scientific treatment, viz:

"Mathematics and physics which are necessary in nautical astronomy, meteorology, hydrography, magnetism in iron ships; spherical astronomy, co-ordinates and their transformations; application of the differential and integral calculus to physics and practical astronomy; the theory of maxima and minima, and the method of least squares. Examples are taken from actual experience in practical life.

"Projections, parallax, occultations of the fixed stars; eclipses, their prediction and reduction of the observations; the theory of instruments, the theodolite, universal instrument, transit instrument, and the practical use of these instruments, with adjustments, are a part of the course.

"The sextant and prismatic circle are studied as far as their use is necessary to seamen.

"The compass and theory of its deviation is made the subject of particular attention, and the examination and adjustment of the compass are carefully studied and practiced. Practice is also required in the reduction of the observations. General and nautical physics, meteorology, hydrography, molecular physics, theory of the earth's magnetism, application of mechanics and physics to ship-sailing, and the theory of chronometers with the sources of errors are all studied.

"Meteorology receives particular attention. The fundamental mathematical theorems of dynamical meteorology and the dynamics of the atmosphere are especially dwelt upon. The construction of synoptic charts is practically carried out, and the weather relations as indicated by them are studied by means of the rich material afforded by the Seewarte."

II.

In order to ascertain facts concerning the actual study of meteorology in the higher schools of Germany, a circular letter, containing the questions given below, was prepared and sent to the rectors of the various institutions; there was also obtained a set of the authorized published lists of lectures and lecturers, in most cases through purchase. The letter of inquiry was addressed to the rectors of the various institutions of learning, in order to obtain the ideas promulgated by the institutions officially, and not the view of any individual who might or might not take an interest in the subject.

The list of schools embraces, not only those in Germany proper, but also those in which the German language is the recognized standard.

To show the nature of the answers desired, the questions were made definite and numbered, and, although it might have been advisable to have arranged them somewhat differently, yet it is believed that enough is gained by them to show us pretty well the status of the science in the schools from which answers were obtained.

Questions submitted in the Circular Letter.

I. Is meteorology systematically taught in your university? How many hours a week?

II. Is it taught by original lectures or by reference to a hand-book? If the latter is the case, what hand-book is used?

III. Is descriptive meteorology taught?

IV. Is climatological meteorology taught in connection with physical geography?

V. Is dynamical meteorology taught? By this is meant the more recent development of meteorology on dynamical principles.

VI. Are the students taught the use or theory of meteorological instruments?

VII. Have you in your physical laboratory apparatus that could be used for investigating questions of physics which have a bearing on meteorology?

VIII. Which of the Professors or Instructors in your university are especially interested in the science of meteorology?

In the following table a summary is given of the answers to the circular, and for those from which no answers were received, data has been supplied from the printed schedules of lecture courses. Those marked *a* were answered by letter, the others were not.

The information in regard to the University of Berlin has been gained by personal inquiry, but the course in mathematical meteorology was not continued during the year because there were not enough applicants for instruction. It was offered, however, for two hours a week. Since the death of Dove until the present year no meteorological lectures have been delivered or projected.

The list of schools is given in alphabetical order.

It will be remembered that the high schools of Germany correspond to the technological institutes of the United States, such, for instance, as the Columbia School of Mines, the Stevens' Institute, the Massachusetts Institute of Technology, &c., &c.

The first column contains merely the index number and the *a* signifying that an answer was received. In the next column we find the names of the schools. In the columns headed I., II., III., IV., V., VI., VII., VIII., are found the answers to the respective questions.

Those from whom no answers were received, and in which there is found no reference to meteorology in their published announced course of study, have been marked "nothing," in the first column. It will be noticed that quite a number of the columns are not filled up, even in those from which answers were received; in these cases the answer was uncertain or that particular question was not answered at all.

The information derived from publications was taken from the official curricula of the institutions for the winter semester 1882–83 and the summer semester 1883. It thus includes one entire school year.

Abstracts of Replies to Questions.

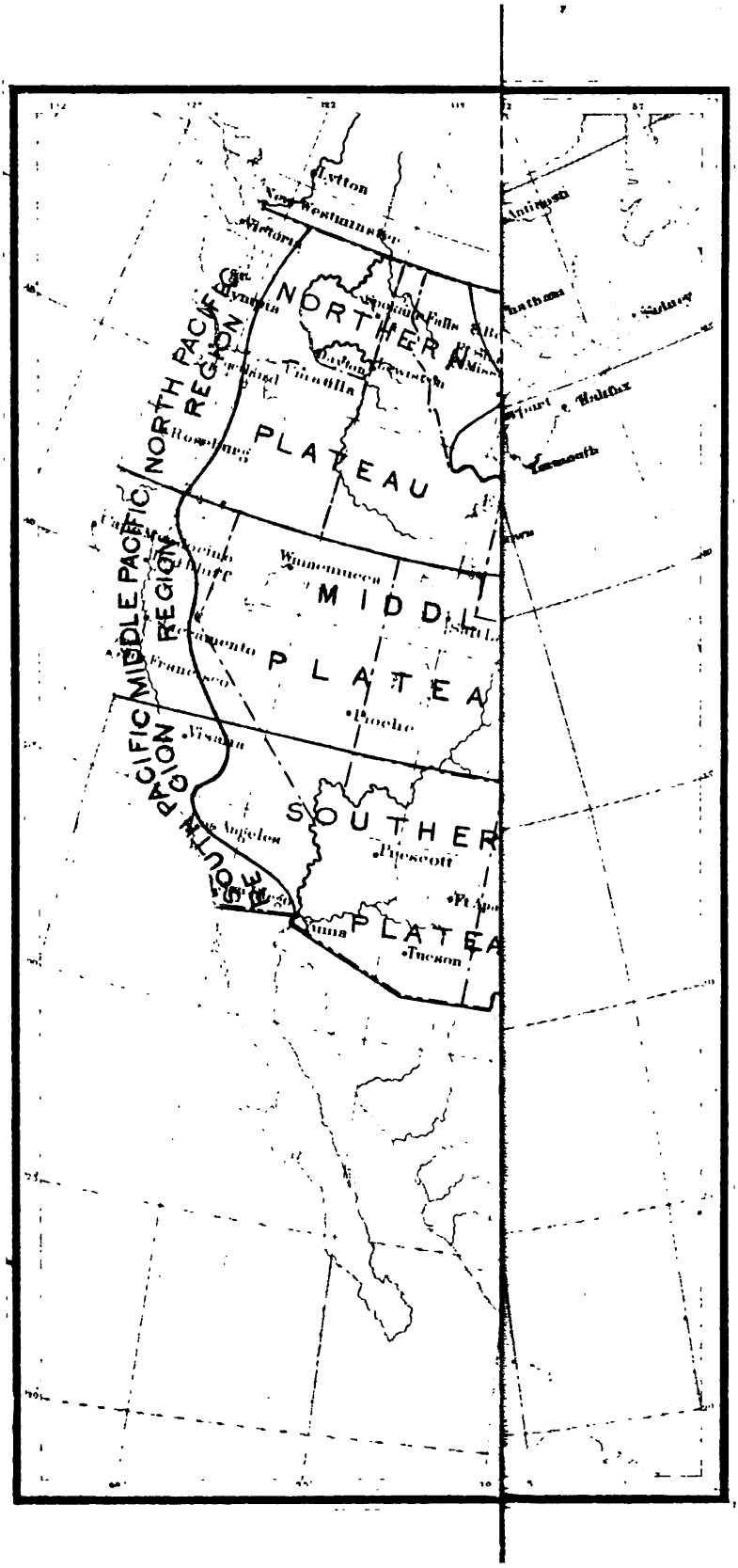
SCHOOLS.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
1. Technical High School at Aachen	Nothing							
2a. University Basel	Yes; twice weekly for half year.	Original lectures	Probably	Probably	Probably in future.	Probably		
3a. Technical High School, Berlin	No	Neither	No	No	No	No	No	
4. University Berlin	Yes; two hours a week.	Original lectures are offered.	Yes	Yes	Yes	Probably	Yes	Dr. Thiesen.
5. University Bern	Nothing							
6a. Technical High School, Brunswick	Yes	No handbook	Yes		Yes	Yes	Meteorological apparatus for lectures.	Dr. H. Weber.
7a. University Breslau	Sometimes taught	No handbook used	Sometimes taught.	Yes	No	In connection with physics, yes.		
8a. University Czernowitz	Not taught separately.	Original lectures		Yes	No	Yes		Prof. Supan, Prof. Handl.
9a. Technical High School, Darmstadt	No	No	No	No	No	Yes	Yes	Mr. Göbel, Prof. E. Dorn.
10. University Dorpat	Yes; two hours a week.	Not known	Probably	Probably	Probably	Probably		
11a. Polytechnic School, Dresden	No	No	No	No	No	No	No	No.
12. University Erlangen	Nothing							
13a. University Freiburg	No	No	No	No	No	No; students may observe at a meteorological station.	Meteorological instruments for physics.	
14a. Technical High School, Graz	Yes; forty lectures a year.	Original lectures	Yes	Yes	No	Yes		Prof. Wilhelm.
15a. University Göttingen	At present, no.	No	No	No	No	No	No	
16a. University Halle	Yes; one to two hours also additional.	Lectures	Yes	Yes	Yes	In experimental physics.	In future, yes	Profs. Knoblauch, Oberbeck, Cornelius, Dr. Lehman.
17. Technical High School, Hanover	Nothing; perhaps in physics.							
18. University Heidelberg	Twice a week for half a year one and a half hours.		Probably	Yes				Prof. Kopp.
19a. University Innsbruck	Yes, but not regularly.	Original	Yes	Yes	Yes	Yes	Yes	Dr. Tollinger, Profs. Torre, Pfaundler.
20. University Jena	Nothing							
21a. Polytechnic School, Karlsruhe	Yes; one hour	Original	General	General	General	Barometer and thermometer.	Yes	Prof. Sohncke.
22a. University Kiel	Yes; twice a week for half year.	Original lectures	Yes	Yes	Uncertain	Yes		

Abstracts of Replies to Questions—Continued.

SCHOOLS.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
23*a*. University Königsberg	Not regularly now, but in future, yes.	Those given are without handbook.	Yes	Yes	Will be given in future.	Yes	No	Prof. Zoppritz.
24*a*. University Leipzig	In past, yes	Original	In past, yes		In past, yes	In physical experiments.	Yes	Prof. Bruns.
25. University Marburg	Probably to some extent.							
26*a*. University Munich	No special lectures.			Yes	No	Yes	Yes	
27*a*. Technical High School, Munich	Yes; twice weekly for half year: also, four times weekly for other half.	Original lectures	Yes	Yes	Yes	Yes		
28. Technical High School, Prague	Probably in connection with physics.					Yes		
29. University Prague	Nothing			Probably				
30*a*. University Rostock	No	No	No	No	No	Yes	Yes	Prof. Mathiessen.
31*a*. University Strassburg	No; probably in future	No	No	No	No	No	No	
32*a*. Polytechnic School, Stuttgart	Yes; from two to four hours a week.	Lectures nearly same as Hann's "Erd-Kunde."	Yes	Yes	Yes	Yes		Prof. Dietrich, Prof. von Schroeder.
33. University Tübingen	Nothing							
34*a*. University Vienna	Yes; two or three hours each week.	Original lectures	Yes	Yes	Yes	Yes	No	Prof. Hann, Prof. Simony.
35. Technical High School, Vienna	Nothing							
36. University Würzburg	Nothing							
37*a*. High School, Zürich	Yes; two hours weekly for half year.	Original lectures	Yes	Yes	Yes	Yes	Yes	Dr. Weilenmann.
38. Polytechnic School, Zürich	Yes; but irregularly. Probably systematically in future.							

It will be seen from the above summary that out of thirty-eight institutions mentioned, twenty-two give instruction in meteorology in some form or other, and this is indeed encouraging.

There has been no discussion of the statistics contained in this paper, because it appeared better to give only the facts and to leave the discussion until data can be secured concerning other countries than Germany, when it will be extremely interesting to bring into one paper a general review of the present condition of the study of meteorology in all countries.


NORTH PACIFIC REGION
NORTHERN PLATEAU
MIDDLE PACIFIC REGION
MIDDLE PLATEAU
SOUTH PACIFIC REGION
SOUTHERN PLATEAU
Lytton
New Westminster
Victoria
Spokane
Pullman
Lewiston
Yakima
Wenatchee
Tacoma
Seattle
Portland
Astoria
Roseburg
Eugene
Salem
Klamath Falls
Bend
Redmond
Prineville
Pendleton
Umatilla
Boise
Twin Falls
Pocatello
Idaho Falls
Butte
Missoula
Helena
Great Falls
Billings
Miles City
Minot
Williston
Regina
Moose Jaw
Swift Current
Medicine Hat
Lethbridge
Calgary
Edmonton
Prince Albert
Saskatoon
Battleford
Yorkton
Brandon
Winnipeg
Portage la Prairie
Dauphin
Prince Rupert
Prince George
Quesnel
Kamloops
Vernon
Nelson
Trail
Penticton
Kelowna
Revelstoke
Kitimat
Terrace
Smithers
Prince Rupert
Vancouver
Victoria
Nanaimo
Courtenay
Campbell River
Port Hardy
Yellowknife
Fort Simpson
Fort Nelson
Fort St. John
Dawson Creek
Grande Prairie
Peace River
Whitehorse
Watson Lake
Dease Lake
Atlin
Carcross
Haines
Skagway
Juneau
Ketchikan
Wrangell
Petersburg
Sitka
Yakutat
Cordova
Valdez
Anchorage
Kodiak
Dutch Harbor
Unalaska
Nome
Kotzebue
Barrow
Fairbanks
Tok
Delta Junction
Northway
Fort Yukon
Circle
Eagle
Tanana
Galena
Bethel
Aleknagik
Dillingham
King Salmon
Kodiak
Homer
Seward
Palmer
Wasilla
Talkeetna
Glennallen
Chitina
McCarthy
Kennicott
Cordova
Valdez
Whittier
Seward
Homer

UNITED STATES OF AMERICA:

WAR DEPARTMENT.

SIGNAL SERVICE NOTES.

No. IX.

WEATHER PROVERBS.

PREPARED UNDER THE DIRECTION OF

BRIG. AND BVT. MAJ. GEN'L W. B. HAZEN,

CHIEF SIGNAL OFFICER OF THE ARMY.

BY

H. H. C. DUNWOODY,

1ST LIEUTENANT, 4TH ARTILLERY, A. S. O. AND ASST.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF WAR.

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1883.

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(IX, XII.)

The study of popular weather prognostics has been considered of such interest that much attention has been given this subject by European meteorologists. It is proposed to make the collection as complete as possible, and, with this in view, it is requested that all popular weather sayings not found in this collection may be communicated to the Chief Signal Officer of the Army. It is proper to add that the weather forecasts of this office are not based upon the proverbs here given, but wholly upon observations and generalizations accepted by meteorologists.

W. B. H.

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OFFICE CHIEF SIGNAL OFFICER,
Washington, D. C., May 11, 1883.

SIR: I have the honor to submit the following report of the "Popular weather proverbs, prognostics, &c.," in use in the United States:

The circular recently issued by you calling upon all observers, both regular and voluntary, and the general public to coöperate with the Signal Service in the collection of this information was widely distributed, and the replies received contain special prognostics in use in each section of this country. Many of these sayings express, in a crude form, the meteorological conditions likely to follow, and have resulted, from the close observation on the part of those whose interests compelled them to be on the alert, in the study of all signs which might enable them to determine approaching weather changes.

The increase of aqueous vapor in the atmosphere is indicated by its effect upon animal and vegetable organization. Animals are observed to become restless before rain, and many prognostics are based upon the action of birds, beasts, fish, reptiles, and insects. Plants and trees also indicate change in the hygrometric condition of the surrounding atmosphere by the expansion and contraction of their leaves or flowers. The increase of aqueous vapor is indicated by the expansion or contraction of various substances, such as wood, whalebone, cat-gut, sponge, and hair, which, when colder than the air, condenses the moisture upon them, and this being absorbed increases the temperature, thus causing expansion or contraction. This action of heat and vapor upon these various substances has been utilized by meteorologists in the construction of hygrometers, and a number of the prognostics herewith express the effect of moisture on the articles named.

I have indicated only a limited number of those prognostics which depend upon the quantity of vapor in the atmosphere with a view of illustrating that a portion of these popular weather sayings are based upon true meteorological conditions, and a thorough knowledge of this class of prognostics may prove of service to the observer when instruments are not at hand.

Those popular sayings referring to years, months, weeks, &c., are not considered of any real value in determining the weather forecasts for the periods named. They are given that general attention may be directed to this class of weather forecasts. The ablest meteorologists of to-day, aided by the most perfect meteorological instruments and the results of years of accurate instrumental observations, are still unable to give reliable forecasts of the weather for a longer period than two or three days, and frequently not longer than twenty-four hours. It is possible that a more accurate observation of the condition of plants or

the condition and action of animals might lead to some valuable suggestion in this important field of investigation. At least we may be permitted to invite a wider field of observation in this branch of the science so long as those most learned in meteorology are unable to inform the agriculturist whether the approaching season will be wet or dry, warm or cold.

I have included in this report the interesting paper on Popular Weather Prognostics by the Hon. Ralph Abercromby, F. M. S., and William Marriott, F. M. S., which was read before the Meteorological Society of London December 20, 1882. This paper is of special value when considered in connection with the popular weather sayings given in this report, as the relation existing between many of these prognostics and the attending meteorological conditions as determined from instrumental observations is clearly shown.

Under head of General Prognostics will be found a paper of special interest by Mr. Cushing, giving weather prognostics in use among the Zuñi Indians of New Mexico.

Part 2 contains the local indications of weather changes as determined by Signal Service observers at several stations of the Signal Service. Also table showing the wet and dry winds of each district for each month of the year, with a district map showing the geographical boundaries of the districts used in the preparation of weather indications of the Signal Service.

I am very respectfully, your obedient servant,

H. H. C. DUNWOODY,

First Lieutenant, Fourth Artillery, A. S. O. and Assistant.

The CHIEF SIGNAL OFFICER, U. S. A.,

Washington, D. C.

CIRCULAR CALLING FOR REPORTS OF POPULAR WEATHER SAYINGS.

WAR DEPARTMENT,
OFFICE OF THE CHIEF SIGNAL OFFICER,
Washington City, ——— —, 188 .

DEAR SIR: It is the purpose of this office to make a collection of the popular weather proverbs and prognostics used throughout the country and by all classes and races of people, including Indians, negroes, and all foreigners. In order to facilitate this work the accompanying questions have been prepared and distributed. If you will kindly lend your assistance in this work I shall be greatly obliged, and if the reports are numerous enough to warrant their printing you shall be furnished with a copy of the paper.

Please write the answers to the questions on the lines provided for that purpose, *and number the answers to correspond with the numbers of the questions answered.* Please add such other information bearing on the subject as you may have. When possible please give the origin and history of the saying or proverb.

Yours, very respectfully,

W. B. HAZEN,
Brig. & Bvt. Maj. Gen'l, Chief Signal Officer, U. S. A.

1. Proverbs relating to the sun.
2. Proverbs relating to the moon. (New moon, change of moon, halo around the moon, influence of moon on agricultural operations, change of moon on days of week, &c.)
3. Proverbs relating to stars and meteors.
4. Proverbs relating to rainbows.
5. Proverbs relating to mist and fog.
6. Proverbs relating to dew.
7. Proverbs relating to clouds.
8. Proverbs relating to frost.
9. Proverbs relating to snow.
10. Proverbs relating to rain. (Morning, midnight, rain from particular quarter, rain during squalls.)
11. Proverbs relating to thunder and lightning. (First thunder in the year, thunder from the west, north, east, south; lightning west, north, northwest, south, southwest, and east.)
12. Proverbs relating to winds. (Day, night, morning, evening; wind and rain, wind preceding fair weather, cold winds, direction of winds, north wind, northeast wind, northwest wind, south wind, east wind, west winds, wet wind, veering winds, backing winds.)
13. Prognostics from the actions of animals. (Bats, oxen, cats, dogs, goats, hares, rabbits, horses, mice, moles, pigs, rats, sheep, weasels, wolves, frogs.)
14. Prognostics from birds. (Blackbirds, cranes, cuckoos, ducks, finches, fowls, chickens, geese, guinea fowl, gulls, kingfishers, kites, larks, migratory birds, owls, peacocks, pigeons, quails, robins, rooks, snipe, sparrows, swallows, swans, thrushes, wild geese, woodpeckers, wrens.)
15. Prognostics from fish. (Carp, dolphin, pike, porpoise, trout, shad, herring, mackerel, cod, blue-fish, lobsters, crabs.)
16. Prognostics from reptiles. (Frogs, glow-worms, leeches, snails, snakes, toads, worms.)
17. Prognostics from insects. (Ants, bees, beetles, crickets, flies, gnats, lady-birds, spiders, wasps.)
18. Prognostics from trees, plants, &c. (Brambles, brooms, chick-weed, clover, colts-foot, dandelions, ferns, fir-cones, hawthorne, marigolds, mushrooms, oak, onions, pear, apple, roses, sea-weed, sensitive-plants, thistles, walnuts, wood-sorrel, chaff, leaves, &c.)
19. Prognostics of the weather drawn from various objects. (Chairs, tables cracked before rain, &c., coals burning brightly, corns, ditches, doors, dust, lamps, rheumatism, salt, seed, sign-boards, smoke, soup, sound, strings, toothache, walls.)
20. Proverbs relating to days of the week. (Weather and agricultural rules.)
21. Proverbs relating to each month of the year. (January, February, March, &c.)
22. Proverbs relating to the seasons of the year. (Spring, autumn, &c.)
23. Proverbs of weather relating to the year.
24. Proverbs of weather and popular sayings relating thereto, not included in the answers to the above questions.

PART I.

POPULAR WEATHER PROGNOSTICS.

By the Hon. RALPH ABERCROMBY, F. M. S., and WILLIAM MARRIOTT, F. M. S., reprinted from the "Quarterly Journal of the Meteorological Society,' published in London.

The attempt to foretell the weather is not of recent date; the ancients carefully studied the sky and clouds, and endeavored to predict the kind of weather that was likely to ensue; and a number of the popular prognostics of the weather of his time are recorded by Aristotle in his work *on meteors*. In later times our forefathers studied the weather, and as they had no instruments to guide them they observed natural objects and noticed the appearances of the sky and clouds, and also the movements of animals, birds, plants, &c. Shepherds and sailors especially being exposed to all kinds of weather, would naturally be on the lookout for any signs of a coming change, and after a time would begin to associate certain appearances with certain kinds of weather. A good deal of weather wisdom of the above character has been thrown into proverbs, trite sayings, and popular verse; and we propose in the present paper to examine and explain some of these by the aid of the most recent discoveries of meteorological science. A great advance has been made in meteorology during the last twenty years, owing to the introduction of daily synoptic charts of the distribution of atmospheric pressure, temperature, wind, rain, &c. From these it is evident that there is a distinct relation existing between the distribution of pressure and the direction and force of the wind, and the temperature and weather generally. A glance at a number of the charts shows that there is nearly always present either an area of low pressure, called a cyclone, usually having an approximately circular form, and, as a rule, moving in an easterly or northeasterly direction; or an area of high pressure, called an anticyclone, also nearly circular in form, but almost stationary in position. The wind in all cases also blows in a direction nearly parallel with the isobars, having the region of lowest pressure on the left hand. This has given rise to the simple law propounded by Dr. Buys Ballot, for the northern hemisphere, viz: "Stand with your back to the wind, and the barometer will be lower on your left hand than on your right." In cyclones the wind circulates in the opposite way to which the hands of a watch move, but exhibits usually a little in-draught; while in anticyclones the wind circulates in the same way as the hands of a watch, but exhibits usually a little outward motion. The intensity of the wind in all cases depends upon the closeness of the isobars; for the closer the isobars the greater is the difference in pressure in a given distance, and consequently the stronger the wind. Nearly all of our weather is of the cyclonic or anticyclonic type, and is entirely dependent upon the form and distribution of the isobars. It is, therefore, by the aid of isobaric charts that we shall attempt to explain popular prognostics, and to associate them with certain kinds of weather. The method of research actually adopted has been for many years past to

take notes of any good observation of any prognostic and put them in a portfolio, with the nearest synoptic chart available, or preferably with the nearest, both before and after. When a sufficient number had been collected they were analyzed, and the remarkable result has been arrived at that the greater number of prognostics are simply descriptive of the weather and appearance of the sky, in the different portions of the various shapes of isobars seen on synoptic charts, and that they indicate foul or fair weather just as they precede the shifting areas of rain or blue sky which are mapped out by the isobaric lines. These charts not only show the success of the prognostics, but also explain wherein they sometimes fail, by tracing the changes of each particular condition of the weather. Hitherto the only prognostics which have been accounted for have been those due to excessive damp, but by means of isobaric charts many others can be readily explained. It must not be supposed that the modern methods diminish the value of prognostics, for even in forecasting weather from synoptic charts they are of great value, and are always exceedingly useful to solitary observers who have only a single barometer to depend upon besides these prognostics, as, for instance, on board ship.

We hope that the present paper will create an interest on the part of many in this subject, and show that it is within their power to assist in advancing the science of meteorology, so that it may not remain any longer in the unsatisfactory state set forth in the following old Bedfordshire lines:

"Well, Duncombe, how will be the weather?"
"Sir, it looks cloudy altogether,
And coming across our Houghton Green,
I stopped and talked with old Frank Beane.
While we stood there, sir, old Jan Swain
Went by and said he knowed 'twould rain;
The next that came was Master Hunt,
And he declared he knew it wouldn't.
And then I met with Farmer Blow,
He plainly said he didn't know,
So, sir, when doctors disagree,
Who's to decide it, you or me?"

CYCLONE PROGNOSTICS.

We shall first take a typical well formed cyclone. In the accompanying diagram (Fig. 1) the broad features of the relation of cloud and rain to a cyclone centre are shown, the full line indicating the path of the depression, and the dotted line at right angles to it is the trough or locus of the lowest reading of the barometer.

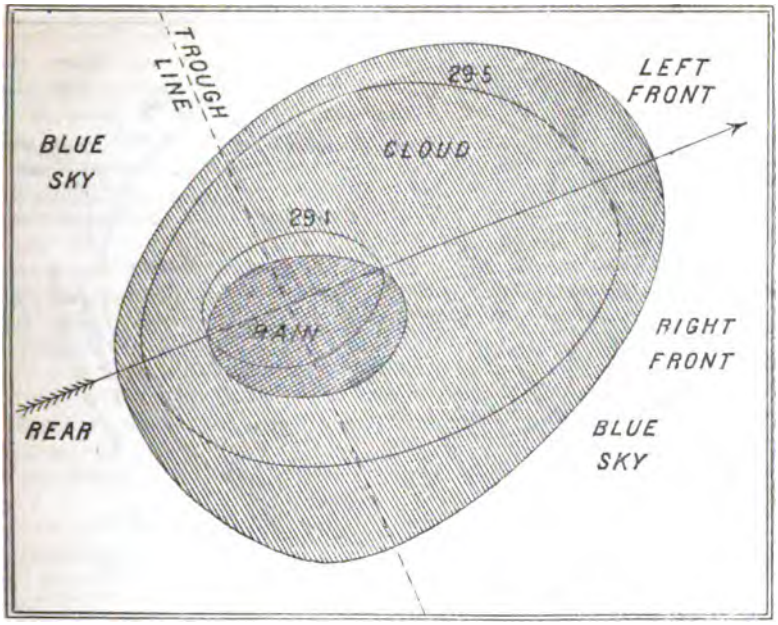

FIG. 1.—WEATHER IN A CYCLONE, NOVEMBER 14, 1875.

In the extreme front of the depression there is a blue sky, then, as the barometer begins to fall, and sometimes even before that takes place, a bank of cirro-stratus, preceded by a halo-bearing sky, makes its appearance, which gradually becomes lower and denser, and forms an overcast, dirty sky. In the whole front of the depression the temperature rises, and the atmosphere feels muggy and close. In the right-hand front the clouds assume the cumulo-stratus type, with driving rain later on. In the left-hand front the air is cooler, but still oppressive, with an easterly wind and overcast sky, succeeded by drizzling rain or ill-defined showers. When the trough of the depression has passed the barometer begins to rise, the wind changes and becomes squally, with showers of rain; the air grows cooler, and the clouds break and ultimately clear away.

Now, with regard to the prognostics with reference to Fig. 2, where

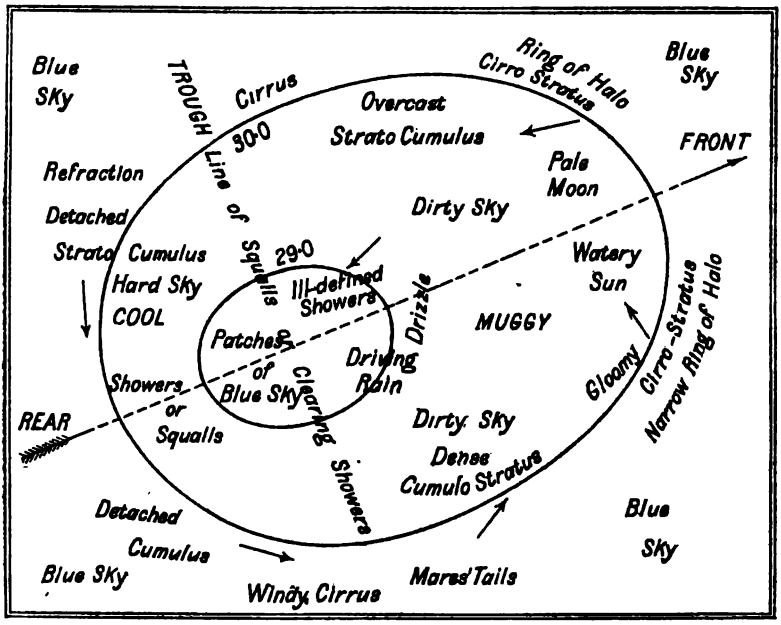

FIG. 2.—CYCLONE PROGNOSTICS.

the characteristic weather in the different portions of a depression are given in a diagrammatic form, it will be seen that the first indication of a coming change is the appearance of a halo round the sun or moon in the cirro-stratus clouds. Hence,

When round the moon there is a brugh,
The weather will be cold and rough.

The moon with a circle brings water in her beak.

Halos predict a storm (rain and wind or snow and wind) at no great distance, and the open side of the halo tells the quarter from which it may be expected.

Mock suns predict a more or less certain change of weather.

With regard to the open side of the halo indicating the quarter from which the storm may be expected, it does not appear that this can be much used as a prognostic. It, however, most probably originated in the fact that halos are often seen in the southwest or west, when the sun or moon is rather low, the lower portion of the halo being cut off by clouds banking up in that direction, and that our storms generally come from those quarters. As a specimen of the value of prognostics we give some details of halos. When rain does not fall within thirty-six hours, any subsequent rain probably belongs to a new depression.

During the six years ending June, 1882, one hundred and fifty-five solar halos and sixty-one lunar halos were observed in the neighborhood of London, and they occurred with the following winds:

	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Total.
Solar halos	9	7	17	8	22	28	59	5	155
Lunar halos	4	3	8	3	8	11	21	3	61
WITH SOLAR HALOS.									
Rain fell on same day	3	1	10	4	15	12	36	0	81
Rain fell on first day	1	2	1	2	2	10	12	1	31
Rain fell on second day	0	0	1	0	2	1	4	2	10
Rain fell on third day	3	1	0	0	0	1	1	1	7
No rain	2	3	5	2	3	4	6	1	26
WITH LUNAR HALOS.									
Rain fell on first day	1	1	3	3	3	9	13	1	34
Rain fell on second day	0	1	0	0	1	1	3	0	6
Rain fell on third day	1	1	2	0	3	1	0	1	9
Rain fell on fourth day	0	0	0	0	0	0	3	1	4
No rain	2	0	3	0	1	0	2	0	8

After the halo comes the pale or watery sun and moon.

When the sun appears of a light, pale color or goes down in a bank of clouds, it indicates the approach or continuance of bad weather.

If the sun goes pale to bed,
'Twill rain to-morrow, it is said.

A red sun has water in his eye.

When the moon has a white look or when her outline is not very clear, rain or snow is looked for.

From the extreme damp in this part of the depression, while the sky generally is pretty clear, cloud forms round and "caps" the tops of hills, a circumstance that has given rise to numerous local sayings:

When the clouds are upon the hills,
They'll come down by the mills.

When Cheviot ye see put on his cap,
Of rain ye'll have a wee bit drap.

If Riving Pike do wear a hood,
Be sure the day will ne'er be good.

When Bredon Hill puts on his hat
Ye man of the vale beware of that.

From the same excessive damp the following may be explained:

When the walls are more than usually damp rain is expected.

Doors and windows are hard to shut in damp weather.

The sailor notes the tightening of the cordage on his ship as a sign of coming rain.

A lump of hemp acts as a good hygrometer, and prognosticates rain when it is damp.

When walls built of stones which have been quarried below high-water mark become damp, wet weather is at hand.

Also, owing to excessive moisture, clouds appear soft and lowering, and reflect the glare of iron-works and the lights of large towns:

The glare of the distant Ayrshire iron-works being seen at night from Cumbrae or Rothsay, rain is expected next day.

In Kinkardine of Monteith (Perthshire) and in all that district the reflections from the clouds of the furnaces of the Devon and Carrow works (to the east) foretell rain next day.

Also:

When the flames of candles flare and snap or burn with an unsteady or dim light, rain, and frequently wind also, are found to follow.

This is especially applicable to oil-lamps or tallow candles.

As the depression approaches and the atmosphere becomes gloomy, close, and muggy, some people are troubled with rheumatic pains and neuralgia, old wounds, and corns are painful, animals and birds are restless, and drains and ditches give out an offensive smell:

When rheumatic people complain of more than ordinary pains in the joints, it will rain.

If corns, wounds, and sores itch or ache more than usual, rain is to fall shortly.

A coming storm your shooting corns presage,
And aches will throb, your hollow tooth will rage.

When animals seek sheltered places instead of spreading over their usual range, an unfavorable change is probable.

Hark! I hear the asses bray,
We shall have some rain to-day.

If oxen turn up their nostrils and sniff the air, or if they lick their fore feet, or lie on their right side, it will rain.

Goats leave the high grounds and seek shelter before a storm.

Hogs crying and running unquietly up and down with hay or litter in their mouths, foreshow a storm to be near at hand.

When birds of long flight—rooks, swallows, or others—hang about home and fly up and down, or low, rain or wind may be expected.

This tumbling of rooks is amongst the best known signs of rain in places where those birds are found.

When the peacock loudly bawls,
Soon we'll have both rain and squalls.

If toads come out of their holes in great numbers, rain will soon fall.

If glow-worms shine much, it will rain.

When gnats bite keenly, and when flies keep near the ground, we look for wind and rain.

When spider-webs are seen floating about in the air, farmers regard it as a sign of coming rain.

When many bees enter the hive and none leave it, rain is near.

Also, from cloud and gloom, plants shut up their petals early:

The *Convolvulus arvensis* (small bind-weed), *Anagallis arvensis* (scarlet pimpernel), and *Calendula pluvialis* shut up their flowers before approaching rain. (The *pimpernel* has been called the poor man's weather-glass.

Dr. Jenner's well-known lines are very good, as they contain references to most of the natural prognostics. (See page 110, General Prognostics.)

It will be seen, however, later on, that the sayings about the rainbow, distant hills, and whirling dust, though good prognostics, do not belong to a depression.

As the depression centre approaches still nearer, rain sets in and continues till the barometer turns to rise. The passage of the trough is often associated with a squall or heavy shower, commonly known as "a clearing shower." Immediately the air becomes cooler and loses the former muggy sensation, and soon small patches of blue sky appear.

When as much blue sky is seen as will make a Dutchman a jacket (or a sailor breeches) the weather may be expected to clear up.

A small cloudless place in the northeast horizon is regarded both by seamen and landsmen as a certain precursor of fine weather or a clearing up.

The steady rain breaks up into showers or cold squalls, which are followed by hard detached cumulus or strato-cumulus till the sky becomes blue again:

When after a shower, the cirro-strati open up at the zenith, leaving broken or ragged edges pointing upwards, and settle down gloomily and compactly on the horizon, wind will follow, and will last for some time.

This is a description of a clearing up before the windy portion of a depression has passed.

In the south of the depression near the outskirts, windy cirrus and "mare's tails" are observed, which indicate wind rather than rain, as they are south of the rainy portion.

The cloud called goat's hair or the gray mare's tails forbodes wind.

If clouds look as if scratched by a hen
Get ready to reef your topsails then.

Mackerel sky and mare's tails,
Make lofty ships carry low sails.

The shift of the wind is different in the right-hand portion of the depression to what it is in the left-hand portion. In the former, on its first approach, the wind backs to south and falls very light to an almost ominous calm. The first puffs or "paws" of wind give rise to a noise in tree tops without much wind, and little eddies of dust, or to a whistling of the wind indoors, which are all well-known signs of rain. Then, as the depression passes along, the wind gradually veers to southwest and west, with increasing strength. Hence,

When the wind veers against the sun,
Trust it not, for back 'twill run.

When the wind is in the south
It is in the rain's mouth.

In the left-hand side of the depression the wind will back right round from south through east to north and northwest. In the rear of the depression on the left-hand side the wind blows from the northeast and then north, when the clouds begin to break and the weather to clear. When the depression has nearly passed away the wind in the rear draws round to the northwest, and gradually abates, and the weather becomes fine. Hence the saying:

Do business with men when the wind is in the northwest.

This bringing the finest weather is said to improve men's tempers, as opposed to the neuralgic and rheumatic sensations felt in front of a depression.

WEDGE-SHAPED ISOBAR PROGNOSTICS.

Though the bulk of British weather is made up of cyclones and anticyclones, there are two other distributions of pressure marked out by wedge-shaped isobars and straight isobars respectively, which have never before been described, but which are associated with many well-known sayings. The chief interest in these prognostics consists in the contrasts which they present to cyclone prognostics, as in many cases they are associated with fine or dry weather, as opposed to the damp of an approaching depression. We shall first describe the prognostics which characterize the wedge-shaped area of high pressure that is frequently formed between a retreating and an advancing depression, as it is by far the most common.

All these prognostics owe their value to the fact that as the new depression comes on, rain may be expected. By reference to Fig. 3 it will be seen that in the rear of the retreating depression the weather is beautifully fine, of the sort of which we should say that it was "too fine to last," or, if it lasted a whole day, we should call it a "pet day."

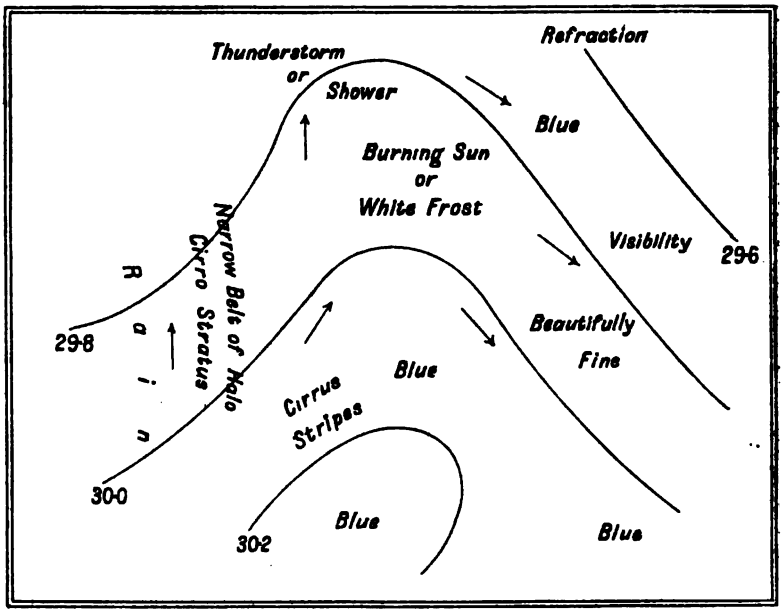

FIG. 3.—WEDGE-SHAPED ISOBARS.

An unseasonably fine day in spring is called a pet day in Scotland. The fate or pets they say awaits it, and they look for bad weather on the morrow.

During the day the sun is burning hot:

When the sun burns more than usual, rain may be expected.

During the night white frost is formed, owing to calm radiation:

A white frost never lasts more than three days; a long frost is a black frost.

Frost suddenly following heavy rain seldom lasts long.

As the day advances after a white frost, the air becomes dull from the influence of the on-coming depression; whence the saying—

When the frost gets into the air it will rain.

During the very fine weather, on the east side of a wedge-shaped area there is often great visibility with a cloudless sky:

The further the sight the nearer the rain.

When the Isle of Wight is seen from Brighton or Worthing, rain may be expected.

When to the people about Arbrouth the Bell-Rock light is particularly brilliant, rain is expected.

About Cape Wrath and along that part of the coast when the Orkney Islands are distinctly seen, a storm or a continuation of bad weather is prognosticated.

When from Ardersier and the adjoining parish on the southeast side of the Moray Firth the distant Ross-shire hills are distinctly seen in the morning rain is expected that day.

To the people in Eaglesham, in Renfrewshire, when the Kilpatrick hills appear near a change to wet is looked for; but when they appear remote, dry weather will continue.

If the old moon embraces the new moon, stormy weather is foreboded.

Great confidence is placed in this old prognostic:

I saw the new moon late yestreen
Wi' the old moon in her arm,
And if we gang to sea, master,
I fear we'll come to harm.

The reason of "visibility" is uncertain; the old idea that it is due to excess of vapor is certainly erroneous. The dry and wet bulb hygrometer always indicates a considerable amount of dryness when it is remarked, and Mr. Cruickshank has shown by long observation at Aberdeen that visibility is greatest at the driest season of the year.

At the extreme northwest edge of a depression there is often unusual "refraction," a well-known sign of rain. This seems to be due to the cold air in the rear of a depression being much below the temperature of the sea. If so, it is a sign of rain, for the reason that one depression is usually followed soon by another, which also explains the saying—

A norwester is not long in debt to a souwester.

Refraction and visibility combined also explain the following curious local prognostic:

When Ailsa Craig is distinctly seen, and seems near at hand, the people of Cumbræ look for change. When the weather is going to be finer it lies flat; but when rain is coming it assumes the form of a mushroom.

Ailsa Craig is an isolated rock standing in the Firth of Clyde, about thirty miles from Cumbræ. It has a conical top, with precipitous sides, so that in ordinary weather only the top is seen lying flat on the horizon; but sometimes in the rear of a depression it appears lifted by refraction, and the light encroaches at the edges, as is often seen with projecting promontories, giving the whole a fanciful resemblance to a mushroom. The prognostic is mistrusted by the inhabitants during frost, and we have proved it by our own observation. On the west side of the wedge-shaped area, as the new depression comes on, the blue sky gradually assumes a dirty appearance, accompanied by a halo, and gathers into cloud, and later on rain begins to fall; while in the southern portion the rain is often preceded by strips of cirrus, either lying in the direction of the wind, or sometimes at right angles to it:

Cirrus at right angles to the wind is a sign of rain.

STRAIGHT ISOBAR PROGNOSTICS.

Now we come to the consideration of some very interesting rain prognostics associated with straight isobars. While those in a depression are preceded by an almost ominous calm, and a dirty, murky sky, these are associated with a hard sky and blustery wind, of which it would be ordinarily remarked "that the wind keeps down the rain," or "that when the wind falls it will rain." While also the prognostics which precede cyclone rain hold good for the reason that they are seen in front of the rainy portion, those associated with straight isobars hold good because, though there is little rain actually with them, the area which they cover to-day will probably be covered by a depression to-morrow—the conditions being favorable for the passage of depressions.

On turning to Fig. 4 it will be seen that while the pressure is high to the south, it is generally low to the north, without any definite cyclonic system, and that the isobars run straight nearly east and west.

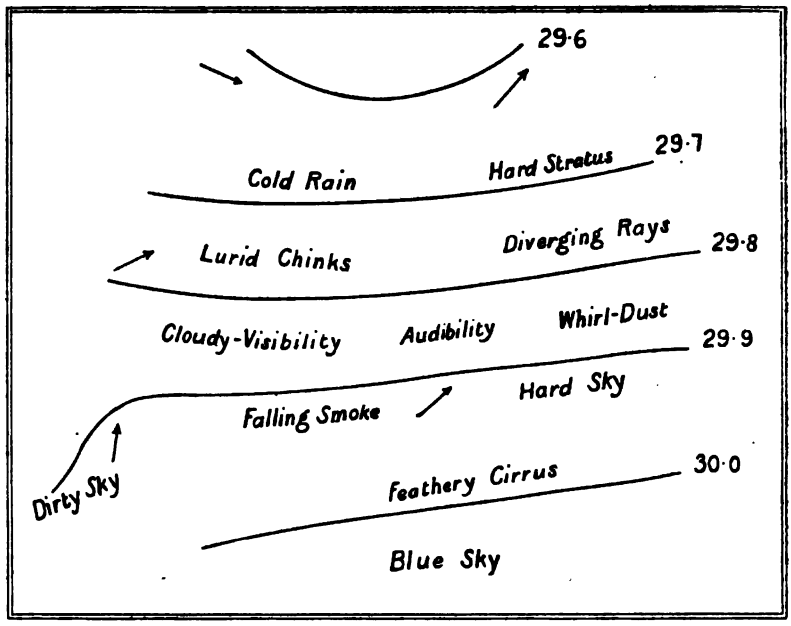

FIG. 4.—STRAIGHT ISOBAR PROGNOSTICS.

Near the high pressure the sky is blue, then as we approach the low pressure feathery cirrus, or some form of windy sky, makes its appearance, while a blustery wind whirls the dust, or blows the soot down; and animals turn their tails to the wind to avoid its force on their faces:

When chimneys smoke and soot falls, bad weather is at hand. The whistling of the wind heard within doors denotes rain.

When sheep, cattle, or horses turn their backs to the wind, it is a sign of rain.

Getting still nearer the low pressure, the sky is found to be gathering into hard stratus, at first with chinks between its masses, through which divergent rays stream down under the sun, which is spoken of as "the sun drawing water." Sometimes, especially in winter, these rays are lurid, and are referred to in the following prognostic:

Along the north shore of the Solway, from Dumfries to Gretna, a lurid appearance in the eastern or southeastern horizon, called from its direction "a Carlisle sky," is thought a sure sign of coming rain. They describe it as lurid and yet yellowish, and the common saying is:

The Carle sky
Keeps not the head dry.

At the same time there is often great "visibility" with a hard overcast sky, and moderately dry air, in which the stratus seems to play the part of a sunshade, for as soon as the sun comes out the clearness of distant objects diminishes. This visibility must not be confounded with the visibility already described with a cloudless sky, which occurs with wedge-shaped isobars. Simultaneously we often find "audibility."

If the noise of a steamer or railway train is heard at a great distance, rain is predicted.

This distinctness of distant sounds must be carefully distinguished from sounds which are not usually heard, being brought up by the wind

coming from a rainy quarter. For instance, the whistle of a railway train to the south of a house will not be usually heard with the normal southwest wind of this country; but when the wind backs in front of a depression to the south, then it will be heard, and although this will be a good prognostic, still it is not true audibility.

When people of Monzie (Perthshire) hear the sound of the waterfalls of Shaggie, or the roar of the distant Turret clearly and loudly, a storm is expected; but if the sound seems to recede from the ear till it is lost in the distance, and if the weather be thick a change to fair may be looked for speedily.

In Fortingall (Perthshire) if, in calm weather, the sound of the rapids on the Lyon is distinctly heard, and if the sound descends with the stream, rainy weather is at hand: but if the sound goes up the stream and dies away in the distance, it is an omen of continued dry weather, or a clearing up if previously thick.

The course of Turret and Lyon is from west to east.

True "audibility" is best described by the saying:

A good hearing day is a sign of wet.
Much sound in the air is a sign of rain.

This last exactly conveys the kind of sound referred to. The reason why audibility is produced is unknown, but the old idea that it is due to excessive moisture in the air is certainly erroneous; in several instances we have observed that the upper current of the wind appeared to be moving much faster than the lower, and perhaps that may have something to do with it. When the gradients are very steep, a little rain sometimes falls with straight isobars, generally in light showers, with a hard sky.

Though as a matter of convenience we have described the sequence of weather as we proceed from high to the low pressure, it must be clearly understood that it does not represent the sequence of weather to a single observer, but rather what the weather will be simultaneously in different parts of the country; for instance, that if there are cirrus clouds in London there may perhaps be a lurid sky in Edinburgh. The prognostic value of all is due to the fact that a depression will soon form which will probably extend over the whole country.

ANTICYCLONE PROGNOSTICS.

Having spoken of cyclones, we shall now direct our attention to anticyclones. In the daily weather charts we sometimes see but two or three isobars, and these are a considerable distance apart, and extend over a large area. The pressure is highest in the centre, and gradually diminishes outwards. The air is calm and cold in the central area, but on the outskirts the wind blows in the direction of the hands of a watch. These are the special features of an anticyclone. The weather in an anticyclone is almost the opposite of that in a depression; that in the latter being wet and unsettled, while that in the former is usually settled and fine, with more or less haze in the air. Another great difference is that while depressions are generally rapid in their movements, anticyclones are nearly stationary; and it is for this reason that they are associated with "settled" fine weather. In the area of high pressure the characteristic features are largely modified by what is termed "radiation" weather, as determined by diurnal and seasonal variations; and as the pressure is nearly stationary, these diurnal and seasonal variations are the chief features of anticyclonic weather.

We shall now give the prognostics due to the variations in some detail, Fig. 5. The sky being generally clear and the air calm, the temperature is high in the day and low at night. In summer brilliant sun

shine prevails during the day, and at night there is heavy dew, and in low-lying places mist.

Heavy dews in hot weather indicate a continuance of fair weather, and no dew after a hot day foretells rain.

If mist rises in low ground and soon vanish, expect fair weather.

Thin, white, fleecy, broken mists, slowly ascending the sides of a mountain whose top is uncovered, predicts a fair day.

When the mist creeps up the hill,
Fisher out and try your skill.

When in the morning the dew is heavy and remains long on the grass, when the fog in the valleys is slowly dissipated and lingers on the hill-side, when the clouds seem

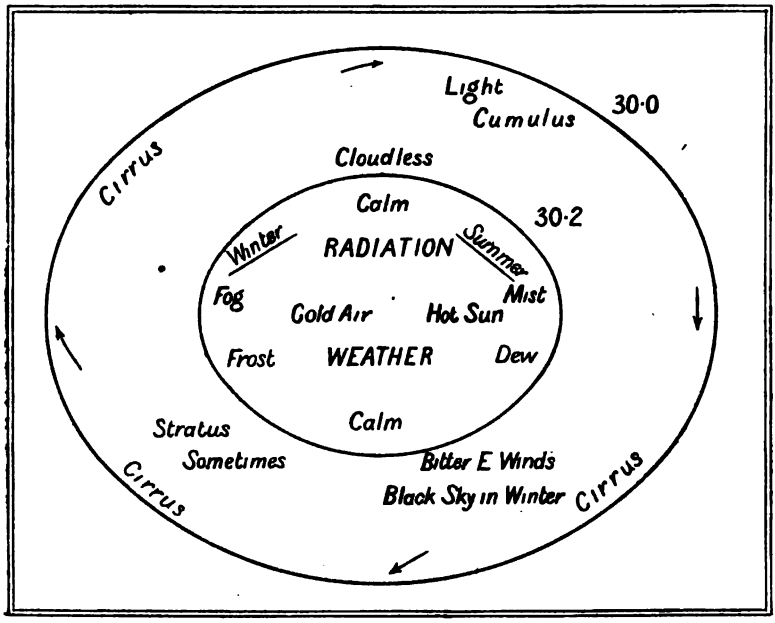

Fig. 5.—Anticyclone Prognostics.

to be taking a higher place, and when a few loose cirro-strati float gently along, serene weather may confidently be expected for the greater part of that day.

These all refer to night radiation, mist being dispersed by the sun's rays. Fine, light, genial weather raises the spirits and exerts an enlivening influence not only on human beings but also on animals, birds, insects, &c. Hence the saying:

If larks fly high and sing long, expect fine weather.

When sea-birds fly out early and far to seaward, moderate winds and fair weather may be expected.

If rooks go far abroad it will be fine.

Cranes soaring aloft and quietly in the air foreshow fair weather.

If kites fly high, fine weather is at hand.

Wild geese, wild geese, ganging out to sea,
Good weather it will be.

When owls whoop much at night, expect fair weather.

Bats, or flying mice, coming out of their holes quickly after sunset and sporting in the open air premonstrates fair and calm weather.

Chickweed expands its leaves boldly and fully when fine weather is to follow.

In winter frost is generally prevalent in the central area of an anticyclone, accompanied frequently by fog, which is most dense in the neighborhood of large towns. This is all due to the radiation of calm weather.

White mist in winter indicates frost.

In the evenings of autumn and spring vapor arising from a river is regarded as a sure indication of coming frost.

This comes from the air being colder than the water.

When fires burn faster than usual, and with a blue flame, frosty weather may be expected.

This is caused by reduced temperature of the outer air making a better draught in the chimney.

In winter when the sound of the breakers on shore is unusually distinct, frost is indicated.

These last two prognostics are explained by the fact that the atmosphere is very dense and still in an anticyclone.

In those places where fog does not form the sky will often be clear at night, whence—

Clear moon,
Frost soon.

In winter when the moon's horns are sharp and well defined, frost is expected.

The wind in an anticyclone system blows in the direction of motion of the hands of a watch, but slightly outwards, and as the anticyclone is nearly always stationary, the wind blows from the same quarter for several days together.

When the wind turns from northeast to east and continues two days without rain, and does not turn south the third day, nor rain the third day, it is likely to continue northeast for eight or nine days, all fair, and then come to the south again.

If the wind is northeast three days without rain,
Eight days will pass before south wind again.

The wind is usually very light in force.

It is said to be a sign of continued good weather when the wind so changes during the day as to follow the sun.

If wind follows sun's course, expect fair weather.

This "veering with the sun," as it is called, is the ordinary diurnal variation of the wind, which in this country is very obvious with the shallow gradients of an anticyclone. At sea-side places in summer very often "the wind is in by day and out by night," which is the equivalent of the land and sea breezes of the tropics. Like two preceding prognostics, it is only in anticyclones that local currents of air, probably due to unequal heating of sea and land, can override the general circulation of the atmosphere in this country.

Sometimes in winter, on the southern side of the anticyclone, bitter east winds, with a black-looking sky, will prevail for several days together, when it may be truly said:

When the wind is in the east
'Tis neither good for man nor beast.

Sometimes also the sky in this region will be covered with a uniform stratus cloud, which is not of any great thickness, and when breaks occur, the sun is seen to be shining brightly above.

On the northeast side of the anticyclone in summer, light, cumulus

clouds frequently form in the morning, gradually increase till after the maximum temperature has passed, and then decrease and disappear towards evening.

If woollen fleeces spread the heavenly way,
Be sure no rain disturbs the summer day.

When the cumulus clouds are smaller at sunset than they were at noon, expect fair weather.

Clouds small and round like a dapple gray with a north wind, fair weather for two or three days.

The cirrus cloud is usually seen on the outskirts of an anticyclone, if in the front it gradually disappears, but if in the rear it is a sign that there will be a change in the weather, hence:

If cirrus clouds dissolve and appear to vanish, it is an indication of fine weather.

If cirrus clouds form in fine weather with a falling barometer, it is almost sure to rain.

When, after a clear frost, long streaks of cirrus are seen with their ends bending towards each other as they recede from the zenith, and when they point to the northeast, a thaw and a southwest wind may be expected.

Both these latter prognostics refer to a depression coming in and "breaking up the weather" and the anticyclone.

CONCLUSION.

We have endeavored in this paper to deal with such prognostics as can be readily classified, but besides these there are many more, what may be termed unclassified prognostics. Our object has been to show the relation between certain prognostics and certain forms of isobars, and by this means to assign them their proper value. It cannot be doubted that if careful attention were given to the observation of the aspect of the sky, the different forms of cloud and local signs, these would prove, even in conjunction with a single barometer reading, of great assistance in predicting the weather. Of course those persons who live in the neighborhood of large towns labor under a great disadvantage, as the sky has nearly always a dirty appearance, and is frequently obscured by smoke. For this reason London is about the worst place to reside in for studying the weather.

We have only been able to give the rudiments of the new method of considering prognostics, for the method is capable of great extension, and we hope that we may succeed in interesting some of the Fellows sufficiently to induce them to observe prognostics in conjunction with the daily weather charts.

In conclusion, we would venture to express our opinion that the observation of local signs of weather ought to form a most important element in all arrangements for telegraphic reporting for the purpose of forecasts, and that the duty should be impressed upon the observers of reporting at once important changes in the local and general signs of the weather. Great attention should also be paid to the observation of the forms and motion of clouds, and as considerable lack of knowledge prevails, even on the part of good observers, regarding the different forms and modifications of clouds, we are glad to see that the meteorological office has already commenced systematic observations of cirrus clouds. Telegraphic observers should be specially instructed in cloud observations and prognostics by some one thoroughly well versed in the subject, so that there may be strict uniformity among all the observers, but we admit that the proposal presents serious difficulties in the way of realization.

Theoretically, when the isobars are well defined we ought to be able to write down the prognostics which might be visible, but practically we cannot do so. Besides, there are sometimes cases of isobars which have no well-defined shape, but with which thunder-storms or heavy showers often occur. These, as is well known, do not affect the barometer, but are abundantly forewarned by the commonest prognostics, and as the rainfall is usually heavy in them the failure of the forecast which omits to notice them is very conspicuous.

The scope of this paper precludes us from entering into the complicated question of the non-cyclonic rainfalls in this country. It will be enough to state that the prognostics which precede them are rather those associated with broken weather, such as bright sunrises or heavy clouds banking up without the barometer falling, than the muggy, dirty weather of a cyclone front. The warning they give is also much shorter, rarely more than three or four hours, if so long.

The result of this paper may be summarized as follows:

The authors explain over one hundred prognostics by showing that they make their appearance in definite positions relative to the areas of high and low atmospheric pressure shown in synoptic charts. The method adopted not only explains many that have not hitherto been accounted for, but enables the failure as well as the success of any prognostic to be traced by following the history of the weather of the day on a synoptic chart. The forms discussed are cyclones, anticyclones, wedge-shaped and straight isobars. The details of weather in the last two are now described for the first time. They also point out that prognostics will never be superseded for use at sea and other solitary situations, and that prognostics can be usefully combined with charts in synoptic forecasting, especially in certain classes of showers and thunder-storms which do not affect the readings of the barometer.*

DISCUSSION.

Dr. Tripe said that some of the Fellows might think the paper hardly suitable for reading at a meeting or printing in the journal of a scientific society, but many of them took an interest in such papers, because they were comparatively simple. In reference to the table of solar and lunar halos in connection with rainfall, it appeared that rain was pretty sure to fall within three days after the occurrence of a lunar halo, and to the extent of 80 per cent., as regards solar halos, on the first or second day.† He considered visibility was a good prognostic, and afforded a more certain indication of the speedy occurrence of rain than even mare's-tails. What caused visibility was unknown to him. The prediction of rain from damp walls depended chiefly on

* The prognostics quoted in the paper have been mostly taken from the following works:

"Popular Weather Prognostics of Scotland." By Arthur Mitchell, M. D., Edinburgh, New Philosophical Journal. "Weather Lore." By Richard Inwards, F. M. S., London, 1869. "A Handbook of Weather Lore." By Rev. C. Swainson, M. A., Edinburgh, 1873.

† The calculation on which his remark on halos was founded is as follows:

Rain occurred in connection with—

	Solar halos.			Lunar halos.		
Direction of wind	S.	SW.	W.	S.	SW.	W.
Number of observations	22	28	59	8	11	21
Rain within forty-eight hours.....per cent..	79	78	81	50	91	76
Rain on third day.....do....	9	3	7	40	9	0

the previous weather; a sudden change from cold to warm would have the effect of making walls condense the moisture contained in the air without approaching rain. The falling of soot down a chimney was, he thought, hardly a good prognostic; it was caused to a great extent by the direction and force of the wind, and also the angle at which the wind struck the chimney-pot. He considered the paper a good one, and a step in the right direction.

Dr. Marces said, with regard to visibility being a sign of rain, he had himself observed on the borders of the Lake of Geneva, that if the mountains on the opposite side of the lake could be seen very distinctly on a cloudy day, rain was likely to fall within a short period. On such occasions the coast appeared much nearer than usual. The late Professor de la Rive, of Geneva, ascribed this phenomenon to the atmospheric dust being hygrometric and becoming transparent in damp weather from the moisture it absorbed.

Mr. Stanley remarked that solar and lunar halos depended upon the moisture in the air, and that a sign of rain could be better assured by reference to the hygrometers. He thought that fine weather in front of a cyclone was due to increase of pressure, and therefore of temperature, caused by the onward march of the cyclone. This increase of temperature was known to render sound more audible, and by making the air clearer distant objects became more visible. It was known that condensed vapors disappeared under a slight increase of pressure, just as, conversely, under the ordinary air-pump, vapors appeared on a diminution of pressure. He considered that the fall of rain in the centre of a cyclone was caused by the increase of pressure due to the tangential action of the air in the cyclone. The straight isobars described in the paper, were, he thought, in segments of a very large cyclone, which was general in all large displacements of air.

Captain Toynbee thought that the great clearness of the air experienced when isobars took the wedge-shaped form, was due to the fact that such isobars represented a ridge of high barometrical pressure, which lay between two cyclonic systems, and that the high pressure of the ridge was maintained by air which had previously risen in front of the advancing cyclonic system, when it had lost most of its moisture, and now came down as a dry, pure, clear, northwesterly wind. Hence the clearness of the air was, where wedge-shaped isobars were being experienced, a sign of rain, because it indicated the fact that a cyclonic system would soon advance over the same position. This explanation was based upon the Rev. W. Clement Ley's theory of the motion of air in cyclonic systems.

Mr. Scott thought that it might have been desirable to give the authorities or sources from which some of the principal sayings had been derived, in order to show which were general and which were of more local import. Reference had also been made to the prevalence of bad smells with a falling barometer, and to the fact that rheumatic affections and neuralgia were felt especially at such a time; but no attempt had been made to explain the connection of those phenomena. It was a well-known fact that a sudden reduction of pressure, such as that experienced by divers when they returned to the surface of the water, produced neuralgic affections. The authors had described straight line isobars and their accompanying prognostics, but only for west winds, for pressure lowest in the north. He should be glad to see the list of prognostics extended so as to include those for straight isobars with east winds when the pressure was lowest in the south. With regard to refraction being a prognostic of rain, in some cases it was a prognostic

of easterly winds, and was recognized as such in the west of Cornwall. In the past summer he had himself verified this latter statement on several occasions at Scilly and the Land's End. The authors, he thought, spoke a little too strongly when they said the barometer gave no sign of thunder-storms. The type of isobar which accompanied these was well known; it exhibited small undulations or incipient bights representing imperfectly formed secondary depressions. At the same time he must say that no one yet, in Europe at least, had been able to forecast correctly the amount of rain for a given day in a given place. The probability of some rain could be recognized, but no attempt could be made to estimate its amount. This was apparently owing to ignorance of the conditions of the upper atmosphere.

Mr. Dyason expressed an opinion that the formulaters of weather prognostics in the past must have been color-blind, an affliction from which he was not sure that the authors of the paper were exempt. "Where are the scarlet, orange, green or gold harmonious, and the general glow?" He had endeavored in a series of sketches of skies and clouds to portray the colors as they presented themselves to his mind. In relation to visibility he referred to the Lakes of Geneva and Lucerne, quoting the lines used in the locality of Mont P

> Si Pilate a un chapeau, le temps se mettra au beau;
> A-t-il un collier, on peut la montée risquer;
> Mais s'il porte son épeé, il y aura une ondée.

Mr. Dyason exhibited a sketch of the Matterhorn taken south of Zermatt during intense visibility. He did not admit "that London was a bad place for skies;" those he now exhibited were sketched in a north-western suburb of the metropolis.

Professor Archibald considered that some of theprognostics mentioned in the paper required more explanation. For instance, it was stated that candles burned with an unsteady light in damp weather, but no reason was given why they should do so. One very good prognostic in use in Scotland appeared to have been omitted, namely: "The northwest wind is a gentleman, and goes to bed." He would also like to know why fires burned with a blue flame in frosty weather. He considered that visibility was often a local phenomenon connected with temperature. He had noticed intense visibility and a fog in juxtaposition on that very day, when travelling from Tunbridge Wells to London.

Mr. Symons pointed out that although it might be useful to trace the origin of some of the weather proverbs, it would be extremely difficult and perhaps impossible, as some of them were ancient. With regard to the connection between lunar halos and rainfall, he thought that it would be curious, considering the large number of wet days in this country, rain falling on an average every other day, if some of them did not happen to follow lunar halos. Respecting doors and windows sticking in damp weather, this was rather the result of existing damp than a forecast of more damp to come; for if existing damp foretold coming damp it was not easy to see how dry weather could ever occur. With regard to visibility, he was glad the authors had referred to Mr. Cruickshank's observations at Aberdeen, extending over twenty-one years, and Mr. Symons thought that much might be learned from a thorough discussion of similar observations.

Mr. Wilson directed attention to Professor Tyndall's theory, that audibility was due to the homogeneity of the atmosphere.

Mr. C. Harding thought that the paper would be useful to an isolated observer, whose forecast was dependent upon his own observation. It

appeared to him that in classifying the prognostics, the authors of the paper had rather begged the question—given a certain occurrence which was admittedly a prognostic of bad weather; this seems to have been consequently classed as belonging to the front half of a cyclonic disturbance. He suggested that with each occurrence of the prognostic in question it would be better to note the existing conditions of atmospheric distribution, and, finally, to classify by actual observation. He stated that the form of isobars described by the authors as wedge-shaped had been referred to many years ago in various publications, by Captain Toynbee, as a "ridge" of pressure. Some distinction should have been made between the weather of anticyclone in summer and in winter, as it differed materially. Audibility had been referred to as a sign of bad weather; he might say that it was notorious in ballooning that for a given distance sounds could be heard more distinctly than on the earth, and in a recent ascent he had noticed that the shrill voices of children were much more audible than the voices of grown persons.

Mr. Abercromby, replying, said that Doctor Tripe's analysis of halos was interesting, but that if rain did not fall within twenty-four hours after a halo, any rain after that would not be due to the cyclone which produced the halo, but to a new one. Damp walls were certainly due to excess of vapor, not to rapid changes of temperature. Soot was doubtless blown down by wind, but when used as a prognostic it rather referred to soot falling out of doors, and was to be attributed to excessive damp. Halos were unquestionably due to the presence of a thin film of ice-formed cloud, and not merely to the amount of moisture in the air. This ice film was only formed in front of cyclones or thunder-storms, and for that reason was a sign of rain. With regard to visibility alluded to by several speakers, he could not admit that it was due to excessive moisture, for the hygrometer showed that it was not so. He agreed with Captain Toynbee, so far as believing that there was a descending current of dry, clear air with a northwest wind on the front side of a "wedge," but he doubted if that was the whole explanation. In the centre of anticyclones there was also a descending current of dry air, but no "visibility." The diagram of straight isobars was given for westerly winds, as that type was by far the commonest. Like every other shape of isobars, the details varied with the type of weather in which they occurred. In an elementary paper it was considered inexpedient to go into so much detail. In the case mentioned by Mr. Scott, isobars trending east and west, but sloping towards the south, the same broad features as given in the diagram would be reproduced, but with a harder sky and an east or northeast wind. The prognostics would, however, be much more likely to fail, for cyclones in the northerly or easterly types, to which such isobars would belong, did not follow with the same regularity as in the westerly type. The refraction, which was a prognostic of east winds on the southwest of an anticyclone, was very different from the refraction on the northwest edge of a cyclone, which portended a fresh storm. The chief difference was the haziness of the horizon in the former case as compared with its visibility in the latter. The latter kind was hardly known on the south coast of England. He strongly suspected that the condition common to both kinds was a relatively cool air over a comparatively warm sea. The type of isobar which exhibited incipient "bights" or imperfect secondaries, was doubtless that most frequently associated with thunder-storms, but the kind of thunder-storms alluded to in the paper as showing no trace on the isobars undoubtedly occurred. Any reference to cloud or sky colors was intentionally omitted in this paper, as also to prognostics relating to diurnal winds. Candles burned

badly before rain, probably owing to a stagnant, damp air. Blue flame was owing to the formation of carbonic oxide when a fire burned very red on a frosty night. Doors and windows sticking in damp weather indicated rain because damp preceded the rain area of a cyclone.

The idea suggested by Mr. C. Harding, that because certain prognostics were known to be associated with bad weather, therefore they were classed as belonging to the front of a cyclone, was entirely erroneous, and exactly opposite to what had been done. The method Mr. Abercromby had adopted for the last twelve years had been, when he observed a good example of any prognostic, to make a note and put it by with the nearest synoptic chart for the day, or often with both the preceding and succeeding charts. When a sufficient number had been collected, the charts were examined, and the necessary deductions drawn from them. Thus the charts were classified according to the prognostics associated with them. The results of all these researches had been embodied in the paper, and the important fact deduced was that every portion of every shape of isobars had a characteristic weather and appearance. The general fact of a "wedge" being associated with fine weather had been noticed many years ago by Captain Toynbee, but the details of weather in different portions, and their relations to prognostics, had a considerable amount of novelty.

Mr. Marriott said that it would be impossible to give the authorities or sources from which all the sayings in the paper had been derived, but the foot-note on page 23 contained a list of the works from which the quotations had been made. The authors on the present occasion had only dealt with certain classified prognostics; and this would explain why many others had not been noticed. They hoped, however, to deal with these in a future paper.

POPULAR WEATHER PROVERBS AND PROGNOSTICS.

PROVERBS RELATING TO ANIMALS.

Ass.

An old adage says:

When the ass begins to bray,
Be sure we shall have rain that day.

Beaver.

In early and long winters, the beaver cuts his winter supply of wood and prepares his house one month earlier than in mild, late winters.

Bears.

When bears lay up food in the fall, it indicates a cold winter.

If the tracks of bear are seen after the first fall of snow, an open, mild winter may be expected.

Bears and coons are always restless before rain.

The bear comes out on the 2d of February, and if he sees his shadow, he returns for six weeks.

Expect rain when dogs eat grass.

Buck's Horn.

If dry be the buck's horn
On Holyroad morn,
'Tis worth a vest of gold;
But if wet it be seen
Ere Holyroad e'en,
Bad harvest is foretold.

Bull.

If the bull leads the van in going to pasture, rain must be expected; but if he is careless and allows the cows to precede him, the weather will be uncertain.

Cats.

When cats sneeze it is a sign of rain.

The cardinal point to which a cat turns and washes her face after a rain shows the direction from which the wind will blow.

If the cat is basking in the sun of February, it must go again to the stove in March. (German.)

When cats are snoring foul weather follows.

When cats are washing themselves fair weather follows.

Cats with their tails up and hair apparently electrified indicate approaching wind.

It is a sign of rain if the cat washes her head behind her ear. (Old lady on Cape Cod.)

Cats clean table-legs, tree-trunks, &c., before storms.

When a cat scratches itself, or scratches on a log or tree, it indicates approaching rain.

If sparks are seen when stroking a cat's back, expect a change of weather soon.

When a cat washes her face with her back to the fire expect a thaw in winter.

When cats lie on their head with mouth turned up expect a storm.

Cats purr and wash; dogs eat grass; sheep eagerly eat and turn in the direction of the wind-point; oxen sniff the air, and swine are restless before rain.

Cats have the reputation of being weather-wise, an old notion which has given rise to a most extensive folk-lore. It is almost universally believed that good weather may be expected when the cat washes herself, but bad when she licks her coat against the grain, or washes her face over her ears, or sits with her tail to the fire. As, too, the cat is supposed not only to have a knowledge of the state of the weather, but a certain share in the arrangement of it, it is considered by sailors to be most unwise to provoke a cat. Hence they do not much like to see a cat on board at all, and when one happens to be more frisky than usual they have a popular saying that the cat has a gale of wind in her tail. A charm often resorted to for raising a storm is to throw a cat overboard; but, according to an Hungarian proverb, as a cat does not die in water its paws disturb the surface; hence the flaws on the surface of the water are named by sailors "cat's-paws." In the same way also a large flurry on the water is a "cat's-skin;" and in some parts of England a popular name for the stormy northwest wind is the "cat's-nose."

Chipmunk.

In cold and early winters the chipmunk is very abundant on the south shore of Lake Superior, and are always housed for the winter in October. In short and mild winters they are seen until the 1st of December.

Cattle.

When a storm threatens, if cattle go under trees it will be a shower; if they continue to feed, it will probably be a continuous rain. (New England.)

When cows fail their milk, expect stormy and cold weather.

When cows bellow in the evening, expect snow that night.

In Texas, when cattle hasten to timber, expect a "norther."

When a cow stops and shakes her foot, it indicates that there is bad weather behind her.

When cows refuse to go to pasture in the morning, it will rain before night.

When cattle collect near the barn long before night and remain near the barn till late in the morning, expect a severe winter.

Expect rain when cattle low and gaze at the sky.

Cattle are also said to foreshow rain when they lick their fore-feet, or lie on the right side, or scratch themselves more than they usually do against posts or other objects.

When cattle go out to pasture and lie down early in the day, it indicates early rain.

Deer.

When deer are in gray coat in October, expect a severe winter.

Dogs.

Dogs digging or making deep holes in the ground are said to indicate rain thereby.

If a dog howls when some one leaves the house it indicates rain.

When a dog or cat eats grass in the morning it will certainly rain before night.

When dogs eat grass rain follows.

Dogs refusing meat is an indication of rain.

Donkey.

When the donkey blows his horn
'Tis time to house your hay and corn.

Domestic Animals.

Domestic animals stand with their heads from the coming storm.

Flying-squirrels.

When the flying squirrels sing in midwinter, it indicates an early spring.

Foxes.

Foxes barking at night indicates storm.

Ground-squirrel.

When the ground-squirrel is seen in winter, it is a sign that snow is about over.

Ground-hog.

If on Candlemas day (2d February) it is bright and clear, the ground-hog will stay in its den, thus indicating that more snow and cold are to come; but if it snows or rain he will creep out, as the winter has ended. (German.)

Goat.

The goat will utter her peculiar cry before rain.

Hares.

Hares take to the open country before a snow-storm.

Hogs.

Hogs pick and store straws, leaves, &c., before cold weather.

Hogs rubbing themselves in winter indicates an approaching thaw.

Horse-hair.

If the hair of a horse grows long early, expect an early winter.

The hair of a horse appears rough just before rain.

Horses and cattle.

When horses and cattle stretch out their necks and sniff the air it will rain.

Horses, as well as some other domestic animals, foretell the coming of rain, by starting more than ordinary, and appearing in other respect restless and uneasy on the road.

Horses and mules very lively without apparent cause indicate cold.

When horses assemble in the corner of a field, with heads to leeward, expect rain.

Kine, when they assemble at one end of a field with their tails to windward, often indicate rain or wind. During the dead calm before a storm we may often see them extending their nostrils, with the head upwards, snuffing the air; this prognostic has been noticed of old by Virgil, and after him by Lord Bacon and others.

Mole.

If the mole dig his hole two feet and a half deep, expect a very severe winter; if two feet deep, not so severe; if one foot deep, a mild winter.

When the moles throw up the earth, rain follows soon.

Musk-rat.

The musk-rats build their houses twenty inches higher and very much warmer in early and long winters than in short ones.

Noise.

Animals making unusual noise indicates change of weather.

Oxen and Sheep.

When oxen or sheep collect together as if they were seeking shelter, a storm may be expected. (Apache Indians.)

Pigs.

Pigs uneasy, grunting, and huddling together, indicate cold.

When pigs busy themselves gathering leaves and straw to make a bed (in fall), expect a cold winter.

When in winter pigs rub against the side of their pen, it is a sure sign of a thaw.

If the forward end of a pig's melt is thicker than the other end, the first part of winter will be the colder. If the latter end is thicker, the last part of winter will be the colder.

When pigs go about with sticks in their mouths, expect a "norther" in Texas.

Prairie Dogs.

Prairie dogs bank up their holes with grass and dirt before a storm; if they are playful, it is a sign of fair weather.

Partridges.

Partridges drum only in fall when a mild and open winter follows.

Rabbits.

In cold, long winters rabbits are fat in October and November; in mild and pleasant winters they are poor in those months.

Rabbits seek the woods before a severe storm.

Rats and Mice.

Much noise made by rats and mice indicates rain.

Swine.

If swine be restless and grunt loudly, if they squeal and jerk up their ears, there will be much wind. Whence the proverb, "Pigs can see the wind."

Swine make lairs on south side of shelter before cold weather.

Squirrels, etc.

When squirrels and small animals lay away a larger supply of food than usual, it indicates that a long and severe winter will follow.

When squirrels lay in a winter supply of nuts, expect a cold winter.

When he eats them on the tree,
Weather as warm as warm can be.

When squirrels are scarce in the autumn, it indicates a cold winter.

Sheep.

If sheep ascend hills and scatter, expect clear weather.

Sheep bleat and seek shelter before snow.

You may shear your sheep
When the elder blossoms peep.

Sand Mole.

The sand mole makes a mournful noise just before frost.

Spaniels.

When the spaniel sleeps it indicates rain.

Wolves.

Wolves always howl more before a storm; deer and elk come down from the mountains at least two days before a storm.

If the wolves howl and foxes bark during the winter, expect cold weather.

If wolves howl in the evening, expect a "norther." (Texas.)

Mammals as Weather Prophets.

Dr. C. C. Abbott showed that the autumnal habits of certain animals that are popularly supposed to be indicative of the character of the coming winter could not be depended upon, although by the majority of people living in the country they were considered as sure indications of what the winter would prove to be. Dr. Abbott had kept a careful record, extending over twenty years, regarding the building of winter houses by musk-rats, the storing of nuts by squirrels, and other habits of these mammals, and had found that the habits referred to, or their omission in certain autumns, bore no relation to the character of the coming winter. (Trenton Nat. Hist. Soc., meeting February 13, 1883.)

PROVERBS RELATING TO BIRDS.

Birds of Passage.

When birds of passage arrive early in their southern passage, severe weather may be looked for soon.

When birds cease to sing, rain and thunder will probably occur.

If birds in general pick their feathers, wash themselves, and fly to their nests, expect rain.

A dry summer will follow when birds build their nests in exposed places.

Birds flying in groups during rain or wind indicate hail.

Birds and fowl oiling feathers indicate rain.

Birds singing during rain indicate fair weather.

If birds in the autumn grow tame,
The winter will be too cold for game.

Bats.

Bats flying late in the evening indicate fair weather.

Bats who speak flying tell of rain to-morrow.

If bats flutter and beetles fly about, there will be a fine morrow.

Blackbirds.

Blackbirds' notes are very shrill in advance of rain.

Blackbirds flying south in autumn indicate an approaching cold winter.

Blackbirds bring healthy weather.

Blackbirds flocking in the fall indicate a spell of cold weather.

Buzzards.

A solitary turkey-buzzard at a great altitude indicates rain.

Buzzards flying high indicate fair weather.

Bluebirds.

When bluebirds twitter and sing, they call to each other of rain.

Chickens.

Chickens, when they pick up small stones and pebbles and are more noisy than usual, afford, according to Aratus, a sign of rain. Other authors prognosticate the coming of rain from the habit fowls have of rubbing in the dust and clapping their wings.

When chickens crow before sundown, it is a sign of rain next day.

Chickens are said to be very noisy just before rain and cocks to crow at unusual hours.

If chickens go out in the rain, it will rain all day.

When chickens come down from roost at night, rain will soon follow.

During rain if chickens pay no attention to it, you may expect a continued rain; if they run to shelter, it won't last long.

When chickens light on fences during rain to plume themselves, it will soon clear.

Chimney Swallows.

When chimney swallows circle and call, they speak of rain. (Zuñi Indians.)

Cocks.

Cocks are said to clap their wings in an unusual manner before rain, and hens to rub in the dust and seem very uneasy.

If the cock moult before the hen,
We shall have weather thick and thin;
But if the hen moult before the cock,
We shall have weather hard as a block.

If the cock crows more than usual or earlier, expect rain.

Cormorants.

When cormorants fly from the sea and sea fowls seek their prey in pools or ponds, expect wind.

Cranes.

If cranes appear early in the autumn, expect a severe winter.

There will be no rain the day the crane flies down the creek.

When cranes make a great noise or scream, expect rain.

Cranes follow the last frost.

If cranes come early in autumn, expect a severe winter.

If cranes place their bills under their wings, expect rain.

When the cranes early (in October) fly southward, it indicates a cold winter.

Crows.

One crow flying alone is a sign of foul weather; but if crows fly in pairs, expect fine weather.

If crows fly south, a severe winter may be expected; if they fly north, the reverse.

If the crows make much noise and fly round and round, expect rain.

Cuckoo.

If the cuckoo is heard long after St. John's day, it means harsh times. (German.)

When the cuckoo comes to the bare shorn,
Sell your cow and buy your corn;
But when he comes to the full bit,
Sell your corn and buy your sheep.

In April he opens his bill;
In May he sings all day;
In June he alters his tune;
Come August, go he must.

Cuckoos hallooing in low lands indicate rain; on high lands indicate fair weather.

Dove.

Don't plant your corn when the turtle-dove cries.

Domestic Fowl.

Domestic fowls dress their feathers when the storm is about to cease.

Domestic fowls look toward the sky before rain.

Domestic fowls stand on one leg before cold weather.

When fowls collect together and pick or straighten their feathers, expect a change of weather.

When fowls roost in day-time expect rain.

February Birds.

If birds caught in February are fat and sleek, it is a sign of more cold weather.

Finch.

When the finch chirps, rain follows.

Geese.

Wild geese fly high in pleasant weather and low in bad weather.

The whiteness of a goose's breast-bone indicates the amount of snow during winter.

If the November goose bone be thick,
So will the winter weather be;
If the November goose bone be thin,
So will the winter weather be.

A very heavy plumage of geese in fall indicates an approaching cold winter.

Everything is lovely, and the goose hawks high (not hangs high, as is usually stated). Geese flying high is a sign of fair weather.

If the breast-bone of a goose is red, or has many red spots, expect a cold and stormy winter; but if only a few spots are visible, the winter will be mild.

When you see geese in water washing themselves, expect rain.

Geese wash and sparrows fly in flocks before rain.

When geese fly at ten o'clock, or in the first part of the night, it is a sign of cold weather.

If domestic geese walk east and fly west, expect cold weather.

When geese and ducks go into the water and flap their wings, throwing the water over their backs, rain is approaching.

When geese or ducks stand on one leg, expect cold weather.

To read the winter of any year take the breast-bone of a goose hatched during the preceding spring. The bone is translucent and it will be found to be colored and spotted. The dark color and heavy spots indicate cold. If the spots are of light shade and transparent, wet weather, rain, or snow may be looked for.

Grouse.

When grouse drum at night, Indians predict a deep fall of snow.

Gulls.

Gulls will soar to lofty heights, and circling round utter shrill cries before a storm.

Hawk.

When men-of-war-hawks fly high, it is a sign of a clear sky;
When they fly low, prepare for a blow.

Hedge Sparrow.

If the hedge sparrow is heard before the grape-vine is putting forth its buds, it is said that a good crop is in store.

Heron.

When heron fly up and down as in doubt where to rest, expect rain.

Hen.

When the hen crows, expect a storm within and without.

Jackdaws.

These birds frequent the flocks of rooks, and with them go out to feed, as if they were aware of the superior sagacity of the rook in finding out the most productive pasture, and had learned to avail themselves of it. Starlings sometimes do the same. Sometimes before the change of weather the daws make a great noise in the chimneys wherein they build, and the sound coming down the flue is distinctly heard in the chamber.

Jackdaws are unusually clamorous before rain.

Kites.

Kites flying unusually high are said to indicate fair weather.

Larks.

Larks, when they sing long and fly high, forebode fine weather.

As long as the lark is heard before Candlemas day (in Europe), that long will it be silent afterward on account of cold yet to come. (German.)

Loon.

Hunters say that the direction in which the loon flies in the morning will be the direction of the wind next day.

Larks.

Field larks, congregating in flocks, indicate severe cold.

Magpies.

Magpies, flying three or four together and uttering harsh cries, predict windy weather.

Missel Thrush.

Missel thrush have been observed to sing particularly loud just before a storm.

Martins.

When martins appear, winter has broken.

No killing frost after martins.

Martins fly low before and during rainy weather.

Migratory.

Migratory birds fly south from cold and north from warm weather. When a severe cyclone is near, they become puzzled and fly in circles, dart in the air and can be easily decoyed. (Observer on North Carolina coast.)

Owls.

Owls hooting indicate rain.

If owls scream in foul weather, it will change to fair.

If owls hoot at night, expect fair weather.

The various omens which vulgar credulity has attached to the hooting and screaming of this bird deserve particular attention. When an owl hoots or screeches, sitting on the top of a house or by the side of a window, it is said to foretell death. The fact seems to be this: The owl, as Virgil justly observes, is more noisy at the change of weather, and as it often happens that patients with lingering diseases die at the change of weather so the owl seems, by a mistaken association of ideas, to forbode the calamity. Both the screech owl and the howlet seem to be alluded to among the harmful fowls in Spencer's Fairy Queen.

Screech Owl.

A screeching owl indicates cold or storm.

Parrots.

Parrots whistling indicate rain.

It is said that parrots and canaries dress their feathers and are wakeful the evening before a storm.

Peacocks.

When the peacock's distant voice you hear,
Are you in want of rain? Rejoice, 'tis almost here.

When the peacock loudly bawls
Soon we'll have both rain and squalls.

If the peacock cries when he goes to roost, and, indeed, much at any time, it is a sign of rain.

When peacocks and guinea fowls scream and turkeys gobble, expect rain.

The squalling of the peacock by night often foretells a rainy day.

Peafowl utter loud cries before a storm, and select a low perch.

Petrels.

Petrels gathering under the stern of a ship indicate bad weather.

The stormy petrel is found to be a sure token of stormy weather. When these birds gather in numbers under the wake of a ship, the sailors are sure of an impending tempest.

Pintado.

Before rain the pintados, or guinea fowls called comebacks, squall more than usual.

Pigeons.

Pigeons return home unusually early before rain.

It is a sign of rain when pigeons return slowly to the dovehouses before the usual time of day.

Prairie Chickens.

Prairie chickens coming into the creeks and timber indicate cold weather.

When the prairie chicken sits on the ground with all its feathers ruffled, expect cold weather.

Quail.

When quails are heard in the evening, fair weather is indicated for next day.

Quails are more abundant during an easterly wind.

Red Breasts.

Red breasts grow bolder and perch against the window in advance of unusually severe weather.

Robins.

First robins indicate the approach of spring.

Long and loud singing of robins in the morning denote rain.

Robins will perch on the topmost branches of trees and whistle when a storm is approaching.

Rooks.

If rooks fly irregularly and high, and seem to fall, expect rain.

Rooks dart and swoop through the air, sparrows group together and keep up a discordant chirping before rain.

Rooster.

A crowing rooster during rain indicates fair weather.

When the roosters go crowing to bed they will rise with watery head.

If a rooster crows on the ground, it is a sign of rain; if he crows on the fence, it is a sign of fair weather.

Sea Birds.

If sea birds fly towards land and land birds toward the sea, expect wind without rain.

Sea-gulls.

If sea-gulls fly inland, expect storm.

When sea-gulls fly to land, a storm is at hand.

Snow-birds.

When snow-birds gather in flocks and light on fences and hedges, expect rain.

Storks.

If storks and cranes fly high and steady, expect fair weather.

Summer Birds.

When summer birds take their flight, the summer goes with them.

Swallow.

When swallows in evenings fly high and chirp, fair weather follows; when low, rain follows.

When the swallow's nest is high
The summer is very dry;
When the swallow buildeth low
You can safely reap and sow.

When the swallows fly low, or when the geese fly, expect storm or cold.

Swallows skimming along the ground indicate rain.

Swallows flying low indicate rain.

Circling swallows indicate rain.

Swan.

The swan builds its nest high before high waters, but low when there will not be unusual rains.

Thrush.

When the thrush sings at sunset a fair day will follow.

Turkeys.

Turkeys perched on trees and refusing to descend indicates snow.

Water turkeys flying against the wind indicate falling weather.

Vultures.

Vultures are considered as evil omens, in consequence, probably, of their following armies for the sake of carcasses of the slain, whereon they feed. When they scent carrion at a great distance, they indicate that state of the atmosphere which is favorable to the perception of smells, which often forbodes rain.

Water Fowl.

If water fowl scream more than usual and plunge into water, expect rain.

If water fowl make more noise than usual, also if robins approach nearer houses than usual, expect frost soon.

Wild Ducks.

Wild ducks scattered around the lakes near Lake Superior form

in large flocks and go south one month earlier in cold or early winters than in mild or pleasant winters.

Wild Geese.

Wild geese flying over in great numbers indicates approaching storm.

Wild geese, wild geese, going to the sea,
Good weather it will be;
Wild geese, wild geese, going to the hill,
The weather it will spill.

Wild geese moving south indicates approaching cold weather moving north, indicates that most of winter is over.

When wild geese fly to the southeast in the fall, in Kansas, expect a blizzard.

Wild geese flying directly south and very high indicates a very cold winter. When flying low and remaining along the river they indicate a warm winter in Idaho. For spring, just the reverse when flying north. (Old settler.)

Wild geese flying past large bodies of water indicates change of weather; going south cold, going north warm.

Woodcock.

An early appearance of woodcock indicates the approach of a severe winter.

Woodpecker.

When the woodpecker leaves, expect a hard winter.

When woodpeckers peck low on the trees, expect warm weather.

The ivory-billed woodpecker commencing at the bottom end of a tree and going to the top, removing all the outer bark, indicates a hard winter with deep snow.

Wrens.

When wrens are seen in winter, expect snow.

PROVERBS RELATING TO CLOUDS.

STORM-PRESAGING CLOUDS.

[From the New York Herald.]

An English meteorologist, the Hon. F. A. R. Russell, who for many years has been a cloud observer, has recently given his conclusions as to the predictive value of the upper clouds. As a celebrated example of the clews given by cirrus clouds to coming weather he mentions that the Rev. Mr. Ley, on a fine day, noticing certain indications of the upper clouds in London, telegraphed from the strand to the meteorological office ordering warnings of a heavy thunder-storm for four o'clock that afternoon, which at the preannounced hour came crashing over the metropolis. Mr. Russell's researches lead him to the conviction that the cirrus cloud is often a more timely monitor of approaching storms than the barometer, and that the "bar or ribbed cirrus," though some-

what uncommon, is "at least equal in value to the falling barometer as a danger signal." He finds also that "detached patches of cirrus, like little masses of wool or knotted feathers, in a clear sky and of unusual figure, moving at more than the average rate, precede disturbances of great magnitude."

From Aristotle's time the value of cloud signs in storm and rain prognostications has been recognized, but their interpretation has only recently become possible, since the movement of storm centres over wide areas has been systematically traced. The irregular motions of the high clouds, perhaps more than their forms (presenting the appearance of having been divided and torn by uprushing currents), indicate dangerous cyclones. If the equatorial air current in which cyclones are borne along is undisturbed by a cyclonic vortex, the clouds floating in its higher strata would sail on it at a uniform rate. But if we suppose that a storm is moving in the great current, the ascending air in the storm's centre is ceaselessly invading the cloud stratum above. It is this uprushing air which divides the clouds. But as the interchange between the surface and upper air in the cyclone centre tends to retard the swift upper current which transports the cirriform clouds, the motion of these clouds, both over the storm centre and far out in front of it, must often be retarded. The very rapidly moving cirrus clouds which Mr. Russell says precede great disturbances must precede them at great distances from their centres—a fact which enhances their predictive value and shows the importance of observing them systematically. The terrible loss of life and property in the British gale of October 14, 1881, this writer thinks might have been less had the cloud portents been duly watched and heeded, as the cirrus indications of the day previous gave sufficient warning of the coming storm.

Anvil Clouds.

Anvil-shaped clouds are very likely to be followed by a gale of wind.

Appearances.

Soft-looking delicate clouds foretell fine weather with weak, moderate, or light breezes. Hard edged, oily appearing clouds, wind. A dark, gloomy, blue sky indicates wind; a bright, blue sky clear fine weather. Generally the softer the clouds the less wind. Small inky clouds foretell rain.

Assemblage of Clouds.

If an assemblage of small clouds spread out or become thicker and darker, expect rain.

Against the Wind.

If you see a cloud rise against the wind, when that cloud comes up to you the wind will blow the same way that the cloud came, and the same rule holds good of a clear place when all the sky is equally thick except one clear edge. (Shepherd.)

Bull's Eye.

A small, fast-growing, black cloud in violent motion seen in the tropics, is called the Bull's Eye, and precedes the most terrible hurricanes.

Black Clouds.

Black clouds in the north in winter indicate approaching snow.

Black Scuds.

Small black scuds (clouds), drifting from southwest, is a sign of rain.

Bright—Dark.

If clouds be bright,
'Twill clear to-night;
If clouds be dark,
'Twill rain, do you hark?

Blue Sky.

Enough blue sky in the northwest to make a Scotchman a jacket is a sign of approaching clear weather.

Cirro-Cumuli.

When cirro-cumuli appear in winter expect warm and wet weather. When cirri threads are brushed back from a southerly direction expect rain and wind.

Cirri and Cumulus.

When cirri merge into cerro-stratus, and when cumulus increase towards evening and become lower clouds, expect wet weather.

Cumulus Clouds.

If a fair day, with cumulus clouds, expect rain before night.

Curdly Sky.

A curdly sky will not leave the earth long dry.

A curdly sky will not be twenty-four hours dry.

Cross-Wind Clouds.

If you see clouds going cross wind, there is a storm in the air.

Clouds—Wind.

Clouds flying against the wind indicate unsettled weather.

Dusky Clouds.

Dusky or tarnish-silver colored clouds indicate hail.

Disperse.

When clouds, after a rain, disperse during the night, the weather will not remain clear.

Dark Sky.

If the sky becomes darker without much rain and divides into two layers of clouds, expect sudden gusts of wind.

Dark clouds in the west at sunrise indicate rain on that day.

Equinox.

If it blows in the day it generally hushes toward evening.

The vernal equinoctial gales are stronger than the autumnal.

East Wind.

If rain falls during an east wind, it will continue a full day.

East Clouds.

Clouds in the east, obscuring the sun, indicate fair weather.

Evening and Morning.

Evening red and morning gray will set the traveller on his way. But evening gray and morning red will bring down rain upon his head.

Fair.

If the sky beyond the clouds is blue,
Be glad, there is a picnic for you.

When there is enough clear sky to patch a Dutchman's breeches, expect fair weather.

Fleecy Clouds.

If, in winter, the clouds appear fleecy, with a very blue sky, expect cold rain or snow.

If there be a fleecy sky, unless driving northwest, expect rain.

When the clouds are formed like fleeces, but dense in the middle and bright toward the edge, with the sky bright, they are signs of a frost, with hail, snow, or rain.

If the woolly fleeces strew the heavenly way,
Be sure no rain disturb the summer day.

Fine Weather.

If clouds at the same height drive up with the wind, and gradually become thinner and descend, expect fine weather.

Gusts.

If there be a cloudy sky and dark clouds driving fast under higher clouds, expect violent gusts of wind.

General Cloudiness.

When a general cloudiness covers the sky and small, black fragments of clouds fly underneath, they indicate rain, and probably it will be lasting.

Hen Scarts.

Hen scarts and filly tails
Make lofty ships wear low sails.

High, Dark Clouds.

If high, dark clouds are seen, in spring, winter, or fall, expect cold weather.

Heavy Sky.

If the sky after fine weather becomes heavy with small clouds, expect rain.

High Clouds.

If clouds form high in air in their white trains like locks of wool, they portend wind and probably rain.

Hues.

Clouds being soft, undefined, and feathery, will be fair. Generally, any deep, unusual hue of clouds indicate rain and wind, while the more quiet and moderate tints indicate fair weather.

Heavy Rains.

If clouds float at different heights and rates, but generally in opposite directions, expect heavy rains.

Horizontal Clouds.

Narrow, horizontal red clouds after sunset in the west indicate rain before thirty-six hours.

Hills.

When clouds are on the hills
They'll come down by the mills.

Isolated Clouds.

When on clear days isolated clouds drive over the zenith from the rain-wind side (see table I, part II) storm and rain follow within twenty-four hours.

June.

It never clouds up in a June night for a rain.

Lookout Mountain.

When Lookout Mountain has its cap on, it will rain in six hours.

Low Clouds.

Clouds floating low enough to cast shadows on the ground are usually followed by rain.

Mackerel Sky.

Mackerel sky, mackerel sky,
Never long wet, never long dry.

Mackerel Clouds.

The mackerel clouds always indicate storm if the first appear about 15° north of west. (Kansas.)

Mackerel scales and mare's tails
Make lofty ships carry low sails.

Mackerel clouds in sky,
Expect more wet than dry.

Mountain Clouds.

When the clouds hang on the mountain side after a rain and the sun shines on the top of the mountain, the storm is over. When gray clouds are seen for several days on the tops of high mountains, in the fall, they indicate an early winter. (Apache Indians.)

Mackerel Scales.

Mackerel scales,
Furl your sails.

A mackerel sky,
Not twenty-four hours dry.

Northwest Clouds.

If a layer of thin clouds drive up from the northwest, and under other clouds moving more to the south, expect fine weather.

Opening.

If clouds open and close, rain will continue.

Red Sky.

When it is evening, ye say it will be fair weather, for the sky is red; and in the morning it will be foul weather to-day, for the sky is red and lowering. (Matthew xvi, 2, 3.)

When clouds are gathered toward the sun at setting, with a rosy hue, they foretell rain.

If there be red clouds in the west at sunset it will be fair; if the clouds have a tint of purple it will be very fine, or if red bordered with black in the southeast.

Rounded Clouds.

A cloud with rounded top and flattened base carries rain-fall on its face.

Red clouds at sunrise indicate storm.

Red clouds at sunrise indicate rain on the following day.

Storm.

Behold there ariseth a little cloud out of the sea like a man's hand.

Prepare thy chariot and get thee down that the rain stops thee not. And it came to pass in the mean while, that the heaven was black with clouds and wind and there was great rain. (Kings xviii, 44, 45.)

Stratus.

Stratus or fall cloud is a fog or mist, so called from being strewed along the ground, and from its consisting of particular kinds of clouds, which fall at night-time to the ground. A stratus in the morning, in autumn, often ushers in some of the finest days we enjoy.

Sunday Sunset.

If Sunday sunset is obscured, expect rain before Wednesday.

Salt Lake Valley.

A horizontal streak or band of clouds immediately in front of the mountains on the east side of Salt Lake valley is an indication of rain within one or two days. When black clouds cover the western horizon, rain will follow soon, and extend to the eastward over the valley. (Observer at Salt Lake.)

Storm.

If clouds look like they had been scratched by a hen,
Get ready to reef your top-sails then.

If the clouds be of different heights, the sky being grayish or dirty blue, with hardly any wind stirring, the wind, however, changing from west to south, or sometimes to southeast, without perceptibly increasing in force, expect storm.

South Clouds.

If clouds appear suddenly in the south, expect rain.

Sunrise.

If clouds fly to the west at sunrise, expect fine weather.

If at sunrise many clouds are seen in the west, and disappear, expect fine weather for a short time.

Strips of Clouds.

If long strips of clouds drive at a slow rate high in the air, and gradually become larger, the sky having been previously clear, expect rain.

Streamers.

When streamers point upward, the clouds are falling and rain is at hand. When streamers point downward, the clouds are ascending and drought is at hand.

Salmon Clouds.

A long strip of clouds called a Salmon, or *Noah's Ark*, stretching east and west, is a sign of stormy weather, but when it extends north and south, it is a sign of dry weather.

North and south the sign of drought,
East and west the sign of blast.

Tints.

Light, delicate, quiet tints or colors, with soft, undefined forms of clouds indicate and accompany fair weather; but unusual or gaudy hues, with hard definitely-outlined clouds, foretell rain, and probably stormy weather.

Thin Light Clouds.

If there be a light-blue sky with thin, light, flying clouds, whilst the wind goes to the south, without much increase in force, or a dirty blue sky when no clouds are to be seen, expect storm.

Tails or Feathers.

If there be long points, tails, or feathers hanging from thunder or rain clouds, five or six or more degrees above the horizon, with little wind in summer, thunder may be expected, but storm will be of short duration.

Two Currents.

Two currents of clouds indicate approaching rain, and in summer thunder.

Thunder.

Against much rain the clouds grow rapidly larger, especially before thunder.

Terraces of Clouds.

When the clouds rise in terraces of white, soon will the country of the corn priests be pierced with the arrows of rain. (Zuñi Indians.)

Variety.

The different kinds of clouds indicate rain.

West Clouds.

When ye see a cloud rise out of the west, straightway ye say there cometh a shower, and so it is. (Luke xii, 54.)

Brassy-colored clouds in the west at sunset indicate wind.

White Clouds.

If on a fair day in winter a white bank of clouds arise in the south, expect snow.

If small white clouds are seen to collect together, their edges appearing rough, expect wind.

Wind.

If the wind blow between north and east or east, with clouds for some days, and if clouds be then seen driving from the south high up, rain will follow plentifully, sometimes forty-eight hours after; if after the rain the wind goes to the south or southwest, better weather will follow.

Yellow Sky.

A light yellow sky at sunset presages wind.

A pale yellow sky at sunset presages rain.

PROVERBS RELATING TO DEW.

Absence of Dew.

The absence of dew for three days indicates rain.

If nights three dewless there be,
'Twill rain, you're sure to see.

Easter.

The number of dews before Easter will indicate the number of hoar frosts to occur after Easter, and the number of dews to occur in August.

Heavy Dew.

If there is a heavy dew and it soon dries, expect fine weather; if it remains long on the grass, expect rain in twenty-four hours.

Heavy dew indicates fair weather.

Clouds without dew indicate rain.

If there is a heavy dew it indicates fair weather; no dew indicates rain.

Haying Season.

In haying season, when there is no dew, it indicates rain.

Much dew after a fair day indicates another fair day. A calm and fair day followed by absence of dew indicates rain.

Midnight.

With dew before midnight,
The next day will sure be bright.

Plentiful Dew.

If the dew lies on the grass plentifully after a fair day, it indicates that the following day will be fair. If there is no dew and no wind after a fair day, rain will follow.

Southerly Winds.

A heavy dew in the middle latitudes is said to indicate southerly winds.

A heavy dew with a south to east wind, fair—with a northwest wind, rain. (New England.)

Summer Dew.

During summer a heavy dew is sometimes followed by a southerly wind in the afternoon.

Wet Feet.

If your feet you wet with the dew in the morning, you may keep them dry for the rest of the day.

PROVERBS RELATING TO FISH.

General.

When fish bite readily and swim near the surface, rain may be expected.

Fish become inactive just before thunder showers, silent, and won't bite.

Fish bite the least
With wind in the east.

Fishes in general, both in salt and fresh waters, are observed to sport most and bite more eagerly against rain than at any other time.

Black-fish.

Black-fish in schools indicate an approaching gale.

Blue-fish, pike, etc.

Blue-fish, pike, and other fish jump with head towards the point where a storm is frowning.

The approach of blue-fish to the Middle Atlantic coast is a true indication of a shift of wind to the north within twenty-four or thirty-six hours. The observer furnishing the above states that he has not known this saying to have failed once in the past twenty-five years, and assigns as a reason that in autumn all fish go south, and the blue-fish, it appears, is able to anticipate this change and approaches the coast, where it may strike the feed-fish on their way south.

Clam-Beds.

Air-bubbles over the clam-beds indicate rain.

Porpoises in harbor indicate coming storm.

Cat-fish.

Fish swim up stream, and cat-fish jump out of water before rain.

If the skin on the belly of the cat-fish is unusually thick, it indicates a cold winter; if not, a mild winter will follow. (Negro.)

Cockles.

Cockles and most shell fish are observed against a tempest to have gravel sticking hard unto their shells, as a providence of nature to stay or poise themselves, and to help to weigh them down, if raised from the bottom by surges.

Cod-fish.

The cod is said to take in ballast before a storm. It is said by Sergeant McGillivry, Signal Corps, U. S. A., that there is one instance of this saying well authenticated, as follows: A number of cod were taken twelve hours before a severe gale, and it was found that each had swallowed a number of small stones, some of the stones weighing three or four ounces.

Crabs and Lobsters.

The appearance of crabs and lobsters indicates that spring has come, and that there will be no more freezing weather. Lake Ontario black bass leave shoal water before a thunder-storm. This has been observed twenty-four hours before storm.

Cuttles.

Cuttles, with their many legs, swimming on the top of the water and striving to be above the waves, presage a storm.

Cuttle-fish.

Cuttle-fish swimming on the surface of water indicate the approach of storm.

Dolphins.

Dolphins, as well as porpoises, when they come about a ship, and sport and gambol on the surface of the water, betoken a storm; hence they are regarded as unlucky omens by sailors.

Eels.

If eels are very lively it is a sign of rain.

Equinox.

In equinoctial storms fish bite the best before the sun crosses the line.

Fish—Flies.

When fish jump up after flies expect rain.

Frog-fish.

Frog-fish crawling indicate rain.

Lake Trout.

In the northern lakes of the United States white-fish and lake-trout leave reefs for deep water one month earlier in stormy falls than in mild, calm falls, with little winds. (Chippewa Indians.)

Lobsters and Craw-fish.

When lobsters or craw-fish heighten their holes about the surface of the ground, it is a sign of approaching rain.

Moon.

Fish bite the best when the moon is in the tail.

Mullet.

Mullet run south on the approach of cold northerly wind and rain.

North Wind.

Fishermen in anger froth
When the wind is in the north;
For fish bite the best
When the wind is in the west.

Pike.

When pike lie on the bed of a stream quietly, expect rain or wind.

Porpoises.

Porpoises, when they sport about ships and chase one another as if in play, and indeed their being numerous on the surface of the sea at any time, is rather a stormy sign. The same may be said of dolphins and grampus. That the cause of these motions is some electrical change in the air seems probable. Wilsford, in his Secrets of Nature, tells us "Porpoises or sea-hogs when observed to sport and chase one another about ships, expect then some stormy weather."

Porpoises are said to swim in the direction from which the wind is coming.

Porpoises run into bays and around islands before a storm.

Salmon and Trout.

Salmon and trout plentiful in river (Columbia) show an abundance of rain in the surrounding country by which the river has risen.

Sea-urchins.

Sea-urchins thrusting themselves into the mud, or striving to cover their bodies with sand, foreshow a storm.

Shad.

Shad run south when the weather changes cold.

Shark.

Shark go to sea at the approach of a cold wave.

Skate.

Skate jump in the direction that the next wind will come from.

South Wind.

Wind in the south catch fish in the mouth.

Trout.

Trout bite voraciously before rain.

When trout refuse bait or fly,
There ever is a storm nigh.

Trout and Salmon.

When the trout or salmon-trout jump late in the fall, the Indians of Washington Territory predict an open winter and an open spring.

Trout and Herring.

Trout jump and herring schools more rapidly before rain.

Whales and Porpoises.

When porpoises and whales spout about ships at sea, storm may be expected.

Winds.

The appearance of a great number of fish on the west Gulf coast indicates bad weather and easterly winds.

PROVERBS RELATING TO FOG OR MIST.

August.

The number of August fogs indicate the number of winter mists.

In the Mississippi Valley, when fogs occur in August, expect fever and ague in the following fall.

A fog in August indicates a severe winter and plenty of snow.

Observe on what day in August the first heavy fog occurs, and you may expect a hard frost on the same day in October.

April Fog.

Fog in April foretells a failure of the wheat crop next year. (Alabama.)

If the first three days of April be foggy, there will be a flood in June. (English.)

Continued Fog.

If there be continued fog, expect frost.

Dew.

When the dew is seen shining on the leaves, the mist rolled down from the mountain last night. (Zuñi Indians.)

Damp Fog.

If there be a damp fog or mist, accompanied by wind, expect rain.

Fog Clouds.

When light fog clouds on evenings are observed to rise from the valleys and hang around the summits of mountains, rain follows.

February Fog.

A fog in February indicates a frost in the following May.

Fog Frost.

He that would have a bad day must go out in the fog after a frost.

Frost.

During frosty weather, the dissolution of mist, and the appearance of small detached cerro-cumulus clouds in the elevated regions of the atmosphere are said to foretell that the termination of frost is at hand.

Fog and Rain.

When the fog goes up the hill the rain comes down the mill.

Fog after Frost.

Fog after hard frosts and fog after mild weather indicate a change in weather.

Falling Fog.

When the fog falls fair weather follows; when it rises rain follows.

Heavy Fog.

Heavy fog in winter, when it hangs below trees, is followed by rain.

Hunting and Fishing.

When the fog goes up the mountains you may go hunting; when it comes down the mountain you may go fishing. In the former case it will be fair; in the latter it will rain.

Light Fog.

Light fog passing under sun from south to north in the morning indicates rain in twenty-four or forty-eight hours.

March, May, and August.

So many mists in March we see,
So many frosts in May shall be;
So many fogs in August we see,
So many snows that year will be.

Mirage.

A mirage is followed by a rain. (New England.)

Mist—Sea.

When the mist takes to the sea
Then good weather it will be.

(English.)

Misty Mornings.

Three foggy or misty mornings indicate rain. (Oregon.)

Morning Fogs.

When a morning fog turns into clouds of different layers, the clouds increasing in size, expect a rain.

Mountain Mist.

When mountains extend north and south, if fog or mist comes from the west, expect fair weather. If mist comes from the top of mountains, expect rain in summer, snow in winter. (Apache Indians.)

October Fog.

For every fog in October there will be a snow during the winter; for each heavy fog a heavy snow, and for each light fog a light snow.

Rising Fog.

A rising fog indicates fair weather. If the fog settles down, expect stormy weather.

Seaward and Landward.

Fog from seaward, fair weather; fog from landward, rain. (New England.)

Summer Fog.

A summer fog is a good indication of fair weather.

Southerly Wind.

In summer, when fog comes with a southerly wind it indicates warm weather; when it comes with a northerly wind it is a sign of heavy rain.

Weather.

When the mist is on the hill,
Then good weather it doth spoil.

Winter Fog.

A winter's fog will freeze a dog.

PROVERBS RELATING TO FROST.

Bearded—Frost.

Bearded frost is a forerunner of snow.

Birds of Passage.

If birds of passage arrive early from the north, expect frost.

Corn Frost.

With the coming of frost grows the corn old. (Zuñi Indians.)

Dark-moon Frost.

Frost occurring in the dark of the moon kills fruit, buds, and blossoms; but frost in the light of the moon will not.

Early Frosts.

Early frosts are generally followed by a long and hard winter. Light or white frosts are always followed by wet weather, either the same day or three days after.

Easter Frost.

Past the Easter frost and fruit is safe.

Fences, Trees.

In winter if the fences and trees are covered with white frost, expect a thaw.

Frosty Trees.

If the trees are frosty and the sun takes it away before noon, sign of rain.

First Katydid.

The first frost of the season occurs six week after we hear the first katydid.

Frosts.

Heavy white frost indicates warmer weather.

Black frost indicates dry cold weather.

Bearded frost indicates colder weather and snow.

Frost, Rain.

Hoar frost indicates rain.

Foul Weather.

Frosts end in foul weather.

First Frost.

If the first frost occurs late, the following winter will be mild, but weather variable. If first frost occurs early, it indicates a severe winter.

Gray Sky.

If there be a dark, gray sky, with a south wind, expect frost.

Heavy Frosts.

Heavy frosts are generally followed by fine, clear weather.

Hoar Frost.

If there be an abundance of hoar frost, expect rain.

Ice.

If the ice crack much, expect frost to continue.

June Frosts.

There will be as many frosts in June as there are fogs in February.

Moonlight.

Moonlight nights have the hardest frosts.

Mist.

When the mist is on the hill,
Then good weather it doth spoil;
When the mist takes to the sea,
Then good weather it will be.

(England.)

Rain, Frosts.

Heavy frosts bring heavy rains; no frosts, no rain. (California.)

Six Months.

Six months from last frost to next frost. (South.)

Spider Webs.

Spider webs floating at autumn sunset,
Bring a night frost, this you may bet.

Three Frosts.

Three frosts in succession are a sign of rain.
Three white frosts and then a storm.

White Frost.

A very heavy white frost in winter is followed by a thaw.

White frost on three successive nights indicates a thaw or rain.

Water Snakes.

When small water snakes leave the sand in low damp lands, frosts may be expected in three days. (Apache Indians.)

Wind, Northwest.

Frost will probably occur when the temperature is 40° and the wind northwest.

A high wind prevents frost.

PROVERBS RELATING TO INSECTS.

Ants.

If ants their walls do frequent build,
Rain will from the clouds be spilled.

When ants are situated in low ground, their migration may be taken as an indication of approaching heavy rains.

Expect stormy weather when ants travel in lines, and fair weather when they scatter.

If in the beginning of July the ants are enlarging and building up their piles, an early and cold winter is at hand.

An open ant-hole indicates clear weather; a closed one an approaching storm.

Ants, Crickets, Gnats, etc.

Ants are very busy; gnats bite; crickets are lively; spiders come out of their nests, and flies gather in houses just before rain.

Butterflies.

The early appearance of butterflies is said to indicate fine weather.

When the white butterfly flies from the southwest, expect rain.

When the butterfly comes, comes also the summer. (Zuñi Indians.)

Bees.

When bees remain in their hives or fly but a short distance, expect rain.

Bees early at work will not perform a full day's work.

Bees will not swarm before a near storm.

Bees returning hastily and in large numbers are said to indicate approaching rain, although the weather may be clear.

When bees to distance wing their flight
Days are warm and skies are bright;
But when their flight ends near their home
Stormy weather is sure to come.

A bee was never caught in a shower.

If bees remain in the hive or fly but a short distance from it, expect rain.

Black Insects.

When little black insects appear on the snow, expect a thaw.

Cockroaches.

When cockroaches fly it is a sign of approaching rain.

Crickets.

If the cricket sing louder than usual, expect rain.

Chrysalides.

When the chrysalides are found suspended from the under side of rails, limbs, &c., as if to protect them from rain, expect much rain. If they are found on slender branches, fair weather will last some time. (Western Pennsylvania.)

Fleas.

When fleas do very many grow,
Then 'twill surely rain or snow.

When eager bites the thirsty flea,
Clouds and rain you sure shall see.

Flies.

A fly on your nose you slap and it goes,
If it comes back again it will bring a good rain.

When flies congregate in swarms, rain follows soon.

When flies bite greedily, expect rain.

Fall-bugs.

Fall-bugs begin to chirp six weeks before a frost in the fall.

Fire-flies.

Fire flies in great numbers indicate fair weather.

Garden Spiders.

If the garden spiders break and destroy their webs and creep away, expect continued rain.

Glow-worms.

Before rain:

Glow-worms numerous, clear, and bright,
Illuminate the dewy hills at night.

When the glow-worm glows, dry hot weather follows.

Gossamer.

Gossamer (the fine web of a certain species of spider) is said when abundant in the air to afford a sign of a fine autumn.

Gnats.

Gnats flying in a vortex in the beams of the sun, fair weather will follow; when they frisk about more wildly increasing heat is indicated; when they seek the shade and bite more frequently, the signs are of coming rain.

Gnats in October are a sign of long, fair weather.

Many gnats in spring indicate that the autumn will be warm.

If gnats fly in large numbers, the weather will be fine.

If gnats, flies, &c., bite sharper than usual, expect rain.

When gnats dance in February the husbandmen becomes a beggar.

If gnats fly in compact bodies in the beams of the setting sun, expect fine weather.

If many gnats are seen in the spring, expect a warm autumn.

When gnats dance in March it brings death to sheep. (Dutch.)

Hornets.

Hornets build nests high before warm summers.

When hornets build their nests near the ground, expect a cold and early winter.

House Flies.

House flies coming into the house in great numbers indicate rain.

Harvest Flies.

When harvest flies sing, warm weather will follow.

Insects.

The early appearance of insects indicate an early spring and good crops. (Apache Indians.)

Insects flying in numbers just at evening show change of weather to rain.

Katydids.

Katydids cry three months before frosts. (South.)

Locusts.

When locusts are heard, dry weather will follow, and frost will occur in six weeks.

Spider Webs.

When spiders' webs in air do fly
The spell will soon be very dry.

Spider webs scattered thickly over a field covered with dew glistening in the morning sun indicate rain.

When spiders work at their webs in the morning expect a fair day.

Spiders strengthening their webs indicate rain.

Long single, separate spider webs on grass is a sign of frost next night. (Irish.)

Spiders in motion indicate rain.

If spiders break off and remove their webs, the weather will be wet.

If spiders make new webs and ants build new hills, the weather will be clear.

If the spider works during rain, it is an indication that the weather will soon be clear.

When the spider cleans its web fair weather is indicated.

If spider webs fly in the autumn with a south wind, expect east winds and fine weather.

Spiders generally change their webs once every twenty-four hours. If they make the change between 6 and 7 p. m., expect a fair night. If they change their web in the morning, a fine day may be expected. If they work during rain, expect fine weather soon, and the more active and busy the spider the finer will be the weather.

Spiders, when they are seen crawling on the walls more than usual indicate that rain will probably ensue. This prognostic seldom fails. This has been observed for many years, particularly in winter, but more or less at all times of the year.

If spiders in spinning their webs make the terminating filaments long, we may in proportion to their lengths expect rain.

When you see the ground covered with spider webs which are wet with dew, and there is no dew on the ground, it is a sign of rain before night, for the spiders are putting up umbrellas; but others say when the spiders put out their sunshades it will be a hot day.

Scorpions.

When scorpions crawl expect dry weather.

Tarantulas.

When tarantulas crawl by day, rain will surely come. (California.)

Wasps.

Wasps building nests in exposed places indicate a dry season.

Wasps in great numbers and busy indicate fair and warm weather.

Wood-lice.

If wood-lice run about in great numbers, expect rain.

Worms, Snails, etc.

Worms come forth more abundantly before rain, as do snails, slugs, and almost all our limaceous reptiles.

Yellow Jackets.

Yellow jackets building nests on top of ground indicates an approaching dry season.

PROVERBS RELATING TO THE MOON.

April Full Moon.

Full moon in April brings frost.

A Saturday's Moon.

If it comes once in seven years, comes all too soon.

Bean.

Go plant the bean when the moon is light,
And you will find that this is right;
Plant the potatoes when the moon is dark,
And to this line you always hark;
But if you vary from this rule,
You will find you are a fool;
If you always follow this rule to the end
You will always have money to spend.

Beans.

Plant garden beans when the sign is in the scales they will hang full.

Cloudy Morning.

In the old of the moon a cloudy morning bodes a fair afternoon.

Cool Weather.

When the moon runs high expect cool or cold weather.

New moon far in north in summer, cool weather; in winter, cold.

Change.

If the moon changes (full or new) in fair or warm part of the day, it indicates a warm moon, and if it changes in the cool part of the day, it indicates that the weather will be cool during the moon.

If the moon is rainy throughout, it will be clear at the change, and perhaps the rain will return a few days after.

If there be a change of weather at the time of the quarters (under the same conditions as above), the new condition will probably last some time.

Drought—Flood.

The further the moon is to the south the greater the drought; the further west the greater the flood, and the further northwest the greater the cold.

Dry Weather.

When the horns of the moon are sharp it indicates dry weather.

New moon far in the south indicates dry weather for a month.

Dry Moon.

A dry moon is far north and soon seen.

Day Moon.

When the moon is visible in the day-time, the days are relatively cool.

East Wind.

If the moon changes with the wind in the east, the weather during that moon will be foul.

Fifth Day of Moon.

The fifth day of the new moon indicates the general character of the weather until the full of the moon.

Full Moon.

In Western Kansas it is said that when the moon is near full it never storms.

The full moon eats clouds. (Nautical.)

Fair Moon.

If the moon be fair throughout and rain at the close, the fair weather will probably return on the fourth or fifth day.

Fair Weather.

Phases of the moon occurring in the evening, expect fair weather.

Five Changes.

Five changes of the moon in one month denotes cool weather in summer and cold in winter.

Flood.

Two full moons in a calendar month bring on a flood.

Fine Weather.

If the full moon rises clear, expect fine weather.

Gale Moon.

If the moon is seen between the scud and broken clouds during a gale, it is expected to scuff away the bad weather.

Halo.

The larger the halo about the moon the nearer the rain clouds and the sooner the rain may be expected.

A lunar halo indicates rain, and the number of stars inclosed, the number of days of rain.

The moon with a circle brings water in her beak.

Horns of Moon.

When Luna first her scattered fear recalls,
If with blunt horns she holds the dusky air,
Seamen and swain predict abundant showers.
(Virgil.)

Moon-shield.

If the moon show a silver shield,
Be not afraid to reap your field;
But if she rises halved round,
Soon will tread on deluged ground.

Moon-ring.

Last night the moon had a golden ring,
But to-night no moon I see.

Moon, Wind-clouds, etc.

When first the moon appears if then she shrouds
Her silver crescent, tipped with sable clouds,
Conclude she bodes a tempest on the main,
And brews for fields impetuous floods of rain.
Or if her face with fiery flushings glow,
Expect the rattling wind aloft to blow;
But four nights old (for that is the best sign),
With sharpened horns, if glorious then she shine,
Next day not only that, but all the moon,
Till her revolving race be wholly run,
Are void of tempests both by land and sea.

Moon Halo.

A large ring around the moon and low clouds indicate rain in twenty-four hours; a small ring and high clouds rain in several days.

Moon, Points of.

If the new moon appears with the points of the crescent turned up, the month will be dry. If the points are turned down, it will be wet.

NOTE.—About one-third of the sailors believe in the direct opposite of the above. The belief is explained as follows: 1st. If the crescent will hold water, the month will be dry; if not, it will be wet. 2d. If the Indian hunter could hang his powder-horn on the crescent, he did so and staid at home, because he knew that the woods would be too dry to still hunt. If he could not hang his powder-horn upon the crescent he put it on his shoulder and went hunting, because he knew that the woods would be wet and that he could stalk game noiselessly.

Mist.

If there be a general mist before sunrise near the full of the moon, the weather will be fine for some days.

New Moon.

New moon on its back indicates wind; standing on its point indicates rain in summer and snow in winter. (Dr. John Menual.)

North Wind.

A new moon with a north wind will hold until the full.

North and South Moon.

If the new moon is far north, it will be cold for two weeks, but ir far south, it will be warm.

October Moon.

Full moon in October without frost, no frost till full moon in November.

Old Moon.

In the old of the moon
A cloudy morning means a fair afternoon.

The old moon seen in the new moon's arms is a sign of fair weather.

If the new moon, first quarter, full moon, last quarter occur between

Summer:	12 and 2 a. m.	Fair.
	2 and 4 a. m.	Cold and showers.
	4 and 6 a. m.	Rain.
	6 and 8 a. m.	Wind and rain.
	8 and 10 a. m.	Changeable.
	10 and 12 m.	Frequent showers.
	12 and 2 p. m.	Very rainy.
	2 and 4 p. m.	Changeable.
	4 and 6 p. m.	Fair.
	6 and 8 p. m.	Fair, if wind northwest.
	8 and 10 p. m.	Rainy, if wind south or southwest.
	10 and 12 p. m.	Fair.
Winter:	12 and 2 a. m.	Frost, unless wind southwest.
	2 and 4 a. m.	Snow and stormy.
	4 and 6 a. m.	Rain.
	6 and 8 a. m.	Stormy.
	8 and 10 a. m.	Cold rain, if wind west.
	10 and 12 m.	Cold and high wind.
	12 and 2 p. m.	Snow and rain.
	2 and 4 p. m.	Fair and mild.
	4 and 6 p. m.	Fair.
	6 and 8 p. m.	Fair and frosty, if wind northeast or north.
	8 and 10 p. m.	Rain or snow, if wind south or southwest.
	10 and 12 p. m.	Fair and frosty.

Points of Moon.

If the points of a new moon are up, then, as a rule, no rain will fall that quarter of the moon; a dull pale moon, dry, with halo, indicates poor crops. In the planting season no grain must be planted when halo is around the moon. (Apache Indians.)

Pale rise.

If the full moon rise pale, expect rain.

Rheumatic diseases.

Therefore the moon, the governor of the floods,
Pale in her anger, washes all the air
That rheumatic diseases do abound.
(Shakespeare.)

Red, Dim, or Pale Moon.

A dim or pale moon indicates rain, a red moon indicates wind.

The moon, her face if red be,
Of water speaks she.
(Zuñi Indians.)

If the full moon rises red, expect wind.

When the moon rises red and appears large, with clouds, expect rain in twelve hours.

Rain.

When the moon is darkest near the horizon, expect rain.

When phases of the moon occur in the morning, expect rain.

If the moon turns on its back in the third quarter it is a sign of rain.

The moon, if in house be, cloud it will, rain soon will come. (Zuñi Indians.)

Ruddy.

If on her cheeks you see the maiden's blush,
The ruddy moon foreshows the winds will rush.

South Moon.

A south moon indicates bad weather.

Snow.

As many days old as the moon is at the first snow there will be as many snows before crop-planting time.

Snow coming two or three days after new moon will remain on the ground some time, but that falling just after full moon will soon go off.

There will be as many snow-storms during the winter as the moon is days old at the first snow-storm.

Stars in Halo.

Moon in a circle indicates storm, and number of stars in circle the number of days before storm.

Sixth Day of Moon.

If the weather on the sixth day is the same as that of the fourth day of the moon the same weather will continue during the whole moon. Said to be correct nine times out of twelve. (Spanish.)

Storm.

The rising or the setting of the sun or moon, especially the moon, will be followed by a decrease of a storm which is then prevailing.

Saturday Moon.

A Saturday moon, if it comes once in seven years, it comes too soon. A Friday's moon, come when it will, comes too soon.

Saturday Change.

One Saturday change in the moon is enough, as it is always followed by a severe storm.

Stormy, Wet Weather.

If there be a change from continued stormy or wet to clear and dry weather at the time of a new or full moon, and so remains until the second day of the new or full moon, it will probably remain fine till the following quarter; and if it changes not then, or only for a short time, it usually lasts until the following new or full moon; and if it does not change then, or only for a very short time, it will probably remain fine and dry for four or five weeks.

Threatening Clouds.

Threatening clouds, without rain, in old moon indicate drought.

Thursday.

Thursday before the moon changes rules the moon.

Way to Wane.

The three days of the change of the moon from the way to the wane we get no rain.

Warm Weather.

When the moon runs low, expect warm weather.

Warm and Cold Weather.

If the moon changes in the morning, it indicates warm weather; if in the evening, cold weather.

A change in the moon which occurs between sunrise and sunset will be followed by warm weather; when the change occurs between sunset and sunrise, it will be followed by cold weather.

PROVERBS RELATING TO PLANTS.

Ash Leaves.

When the ash leaves come out before the oak, expect a wet season.

African Marigold.

If this plant does not open its petals by 7 o'clock in the morning, it will rain or thunder that day. It also closes before a storm.

Aspen Leaf.

Trembling of the aspen leaf in calm weather indicates an approaching storm.

Berries.

When the bushes are full of berries, a hard winter is on the way.

When berries are plentiful in the hedge, on the May-bush, and blackthorn, a hard winter may be expected.

Berries in the hedges often forebode a hard winter, and severe weather frequently occurs in seasons when they are particularly plentiful on the May-bush and blackthorn. This rule is not, however, without its exception. But, at all events, peculiarities of the seasons have a wonderful influence on the quantities of berries, particularly those of holly. The peculiarities of the seasons and their influence on plants constitute a very curious subject of research; it comprehends the whole doctrine of special blights, whereby only certain tribes of plants are affected. Epidemics and epizoötics come under the same class, and are referable to specific conditions of the atmosphere.

Beech-nuts.

When beech-nuts are plenty, expect a mild winter.

Beans.

Be it weal or be it woe,
Beans must blow ere May doth go.

Convolvulus.

The convolvulus folds up its petals at the approach of rain.

Cherries.

As long as the cherries bloom in April it is said that the grape-vine will be in bloom.

Chickweed.

The flowers of the chickweed contract before rain.

The chickweed, at 9 o'clock in the morning, if the weather is clear, straightens its flowers, spreads its leaves, and keeps awake until noon. If, however, there is rain in prospect, the plant droops and its flowers do not open.

Corn-husk.

A double husk on corn indicates a severe winter.

Ears of corn are covered with thicker and stronger husks in cold winters.

If corn is hard to husk, expect a hard winter. (Apache Indians).

Cockle-burs.

When cockle-burs mature brown it indicates frost.

Clover Leaves.

Clover leaves turned up so as to show light under-side indicate approaching rain.

Clovers contract at the close of a storm.

Cottonwood—Quaking Asp.

Cottonwood and quaking asp trees turn up their leaves before rain.

Corn-fodder.

Corn-fodder dry and crisp indicates fair weather; but damp and limp, rain—very sensitive to hygrometric changes.

Dandelions.

The dandelions close their blossoms before a storm; the sensitive plant its leaves. The leaves of the May trees bear up so that the under side may be seen before a storm.

Dandelion and Daisy.

The flowers of the dandelion and daisy close before rain.

Dogwood Blossoms.

When the blooms of the dogwood tree are full, expect a cold winter. When blooms of same are light, expect a warm winter.

Frost will not occur after the dogwood blossoms.

Dead Nettles.

Dead nettles blow early and all the year; the red or purple kind are scarce all winter. They afford a sign of a mild season when they come in winter in abundance.

Early Blossoms.

Early blossoms indicate a bad fruit year.

Flowers.

When the perfume of flowers is unusually perceptible, rain may be expected.

Fox-fire.

Fox-fire seen at night indicates cold.

Frost—Cockle.

Frost has never been known to catch the cockle or blackberry in bloom.

Fennel.

When fennel blooms, frost follows.

Fall Apples.

If the fall apples are one-sided, with thick, rough skins, a severe winter may be expected.

Grasses.

Grasses of all kinds are loaded with seeds before a severe winter.

Goat's-beard.

When goat's-beard closes its petals at midday, expect rain.

Hay.

Better it is to rise betimes
And make hay while the sun shines,
Than to believe in tales and lies
Which idle monks and friars devise.
(Robins's Almanac.)

Hog-thistle.

If the hog-thistle closes for the night, expect fair weather; if it remains open, expect rain.

Jonquils.

Jonquils, of which there are several sorts, blow in the open ground in March and April. The great jonquil and the odorous jonquil blow about the middle of March, the lesser or proper jonquil somewhat later. When they blow well and early they forebode a fine season.

Leaves.

If in the fall of the leaves in October many of them wither and hang on the boughs, it betokens a frosty winter and much snow.

If the leaves are slow to fall, expect a cold winter.

If the falling leaves remain under the trees and are not blown away by the wind, expect a fruitful year to follow.

When leaves of trees are thick, expect a cold winter.

Late Blossoms.

Late blossoms indicate a good fruit year.

Marigold.

The marigold opens between 6 and 7 in the morning and generally keeps awake until 4 in the afternoon. In such cases the weather will be steady. If, on the other hand, it does not open by 7 o'clock in the morning, you may expect rain that day.

Milk-weed.

Milk-weed closing at night indicates rain.

Mountain Moss.

When the mountain moss is soft and limpid, expect rain.

When mountain moss is dry and brittle, expect clear weather.

March Flowers.

"March flowers make no summer bowers," because if the spring is very mild, vegetation becomes too far advanced and is liable to injury from frost.

Mushrooms.

When mushrooms spring up during the night, expect rain.

Mushrooms and toad-stools are numerous before rain.

Nuts.

Nuts with a thick covering denote a hard winter.

Onion-skins.

Onion-skins very thin,
Mild winter coming in;
Onion-skins thick and tough,
Coming winter cold and rough.

Pitcher-plant.

The pitcher-plant opens its mouth before rain.

Pimpernel.

When this plant is seen in the morning with its little red flowers widely extended, we may generally expect a fine day; on the contrary, when the petals are closed, rain will soon follow. This plant has been styled the poor man's weather-glass.

Red Sandwort.

When the corona of red sandwort contracts, expect rain.

Sensitive Brier.

The sensitive brier closes up its leaves on the approach of rain.

Sycamore.

Sycamore tree peeling off white in the fall, indicates a cold winter.

Sunflower.

Sunflower raising its head indicates rain.

Scotch Pimpernel.

When the corona, the Scotch pimpernel, contracts, expect rain.

Speedwell.

When the corona of the speedwell, and stitchwort contracts, expect rain.

Sea-weed.

Sea-weed becomes damp and expands before wet weather.

Sea Grape.

In the West Indies and along the coast of Florida there grows a small fruit-bearing tree called the sea grape, which when its fruit is abundant and ripens early it is said by the Seminole Indians and natives of the Bahama Islands to be a sign that there will be a hurricane before the end of the season. The usual time of ripening of this fruit is during September, and the hurricane season extends from the first of August till the end of October.

Silver Maple.

The silver maple shows the lining of its leaf before a storm.

Sea-weed.

A piece of kelp or sea-weed hung up will become damp previous to rain.

Tulips and dandelions close just before rain.

Trefoil.

If the trefoil contracts its leaves, expect heavy rains.

Tree Limbs.

When tree limbs break off during calm expect rain.

Tree Moss.

North side of trees covered with moss indicates cold weather.

Trees.

Trees grow dark before a storm.

Tree Leaves.

When the leaves of trees curl, with the wind from the south, it indicates rain.

Wild Indigo.

Just before rain or heavy dew the wild indigo closes or folds its leaves.

Wheat.

For wheat a peck of dust in
March is worth a king's ransom;
Or wet and soddy, the land
Must go to oats and corn.

PROVERBS RELATING TO RAIN.

Clearness.

Unusual clearness in the atmosphere, objects being seen very distinctly, indicates rain.

Evening and Morning.

Evening red and morning gray
Are sure signs of a fine day.

Evening gray and morning red,
Put on your hat or you'll wet your head.

Electricity.

Increasing atmospheric electricity oxidizes ammonia in the air and forms nitric acid, which affects milk, thus accounting for souring of milk by thunder.

Hours of Commencing.

If rain commences before daylight, it will hold up before 8 a. m.; if it begins about noon, it will continue through the afternoon; if it commences after 9 p. m., it will rain the next day; if it clears off

in the night, it will rain the next day; if the wind is from the northwest or southwest, the storm will be short; if from the northeast, it will be a hard one; if from the northwest, a cold one, and from the southwest a warm one.

If rain ceases after 12 m., it will rain next day.

If rain ceases before 12 m., it will be clear next day.

Morning Rain.

If rain commences before day, it will stop before 8 a. m.; if it begins about noon, it will continue through the afternoon; if not till 5 p. m., it will rain through the night; if it clears off in the night, it will rain the next day.

If it rains before seven,
It will clear before eleven.

If rain begins at early morning light,
'Twill end ere day at noon is bright.

North Rain.

With the north rain leaves the harvest.

Northeast Rain.

With the rain of the northeast comes the ice fruit (hail). (Zuñi Indians.)

Rain from the northeast (in Germany region of dry winds) continues three days.

Notice.

Rain long foretold, long last;
Short notice, soon past.

October and November.

Plenty of rain in October and November on the North Pacific coast indicates a mild winter; little rain in these months will be followed by a severe winter.

Scalp-Locks.

When the locks of the Navajoes turn damp in the scalp-house, surely it will rain.

South Thunder.

Rain with south or southwest thunder, squalls occur late each successive day.

South Rain.

Rain from the south prevents the drought, but rain from the west is always best.

South winds bring rain. (California.)

The south rain brings with it the beautiful odors of the land of everlasting summer and brightens the leaves of growing things. (Zuñi Indians.)

Rain which sets in with a south wind on the north Pacific coast will probably last.

September Rain.

Rain in September is good for the farmer, but poison to the vine growers. (German.)

Seven and Eleven.

If it rains before seven,
It will cease before eleven.

Sunrise.

If it rains before sunrise, expect a fair afternoon.

Sunshiny Rain.

If it rains when the sun shines, it will rain the next day.

Swallows and Crickets.

Rain is indicated when—

Low o'er the grass the swallows wing,
And crickets, too, how sharp they sing.

September.

Heavy September rains bring drought.

Squalls.

When rain-squalls break to the westward, it is a sign of foul weather.

When they break to leeward, it is a sign of fair weather. (North-east coast.)

Tide.

Rain is likely to commence on the turn of the tide.

In threatening, it is more apt to rain at the turn of the tide, especially at high water.

Toad stools.

If toad-stools spring up in the night in dry weather, they indicate rain.

West Rain.

When rain comes from the west it will not continue long.

The west rain comes from the world of waters to moisten the home of the She Wi. (Zuñi Indians.)

Wind and Rain.

Marry the rain to the wind and you have a calm.

Wind.

With the rain before the wind your topsail halyards you must mind.

PROVERBS RELATING TO RAINBOWS.

Clear.

The rainbow has but a bad character: she ever commands the rain to cease.

Color.

If the green be large and bright in the rainbow, it is a sign of rain. If red be the strongest color, there will be rain and wind together. After a long drought the rainbow is a sign of rain. After much wet weather it indicates fair weather. If it breaks up all at

once, there will follow severe and settled weather. If the bow be in the morning, rain will follow; if at noon, slight and heavy rain; if at night, fair weather. The appearance of two or three rainbows indicates fair weather for the present, but settled and heavy rains in a few days.

Evening Rainbow.

If there is a rainbow at eve,
It will rain and leave.

East and West Rainbow.

Rainbow in the east indicates that the following day will be clear. A rainbow in the west is usually followed by more rain the same day.

Rainbow in the Sierras (*i. e.*, in the east) in evening indicates no more rain. (California.)

Fair Weather.

The boding shepherd heaves a sigh,
For see, a rainbow spans the sky.

High Rainbow.

When rainbow does not touch water, clear weather will follow.

Indications by Colors.

The predominance of dark red in the iris shows tempestuous weather; green, rain; and if blue, that the air is clearing.

Low Rainbow.

A rainbow that comes near a camp-fire, or low down on the mountain side, is a bad sign for crops. If seen at a great distance, it indicates fair weather.

Morning and Evening Rainbow.

Rainbow in morning, shepherds take warning;
Rainbow at night, shepherds' delight.

A morning rainbow indicates rain; an evening rainbow, fair weather.

A rainbow in the morn, put your hook in the corn;
A rainbow at eve, put your head in the sheave.

Night and Morning Rainbow.

Rainbow at night, sailors' delight;
Rainbow in morning, sailors' warning.

Spring Rainbow.

A rainbow in spring indicates fair weather for next twenty-four to forty-two hours.

Sudden Disappearance.

If a rainbow disappears suddenly, it indicates fair weather.

West and East Shower.

Rainbow in morning shows that shower is west of us, and that we will probably get it. Rainbow in the evening shows that shower is east of us and is passing off.

PROVERBS RELATING TO REPTILES.

Frogs.

Frogs singing in the evening indicate fair weather for next day.

Frogs croak more noisily, and come abroad in the evening in large numbers, before rain.

When frogs croak three times, it indicates that winter has broken.

As long as frogs are heard before Saint Marc's day, that long will they keep quiet afterward.

Croaking frogs in spring will be three times frozen in.

When frogs warble, they herald rain. (Zuñi Indians.)

Frogs must be frozen up three times in spring after they begin to croak.

The louder the frogs, the more's the rain.

The color of a frog changing from yellow to reddish indicates rain.

Tree-frogs piping during rain indicates continued rain.

Tree-frogs crawl up to the branches of trees before a change of weather.

Yellow Frogs.

Abundance of yellow frogs are accounted a good sign in a hay-field, probably as indicating fine weather.

Glow-worms.

Glow-worms numerous and bright, indicate rain.

Worms.

If, after some days of dry weather, fresh earth is seen which has been thrown up by worms, expect dry weather.

When worms creep out of the ground in great numbers, expect wet weather.

Snails.

Snails moving on bushes or grass, are signs of rain.

When black snails cross your path,
Black clouds much moisture hath.

Leech.

A leech placed in a jar of water will remain at the bottom until rain is approaching, when it will rise to the surface, and if thunder is to follow will frequently crawl out of the water.

Leeches kept in glass jars move about more frequently just before rain.

Lizards.

When lizards chirrup, it is a sure indication of rain.

Snakes.

Hanging a dead snake on a tree will bring rain in a few hours. (Negro.)

NOTE.—Snakes are out before rain, and are, therefore, more easily killed.

In Oregon the approach of snakes indicates that a spell of fine weather will follow.

When snakes are hunting food rain may be expected; after a rain they cannot be found.

Hang up a snake skin and it will bring rain.

Snakes and snake-trails may be seen near houses, roads, &c., before rain.

Snakes expose themselves on the approach of rain.

PROVERBS RELATING TO STARS OR METEORS.

Comets.

Comets bring cold weather.

After an unusual fall of meteors, dry weather is expected. All comets evidence the approach of some calamity, such as drought, famine, war, floods, &c. (Apache Indians.)

Comets are said to improve the grape crop, and wine produced in years when comets appear is called comet wine. (French.)

Falling Stars.

If there be many falling stars during a clear evening in summer, expect thunder.

If there are no falling stars on a bright summer night, expect fine weather.

Fair Weather.

When the stars set still the times are to be pleasant. (Zuñi Indians.)

Flickering.

When the stars flicker in a dark background, rain or snow follows soon.

Huddling Stars.

When the stars begin to huddle,
The earth will soon become a puddle.

Many Stars.

When the sky is very full of stars, expect rain.

Many stars in winter indicate frost.

In summer, when many stars twinkle, clear weather is indicated.

Milky Way.

The edge of the Milky Way, which is the brightest, indicates the direction from which the approaching storm will come.

North Star.

When the stars above 45° in altitude or the North Star flickers strangely, or appears closer than usual, expect rain.

Numerous Stars.

When stars appear to be numerous, very large, and dull, and do not twinkle, expect rain.

Snow.

Many meteors presage much snow next winter.

Shooting Stars.

If meteors shoot toward the north, expect a north wind next day.

Many shooting stars on summer nights indicate hot weather.

Tempest.

When a star tows the moon and another chases her astern, tempestuous weather will follow. The phenomenon is probably styled a big star chasing the moon. (Nautical.)

Twinkling.

Excessive twinkling of stars indicates very heavy dews, rain, and snow.

When the stars twinkle very brightly, expect stormy weather in the near future.

The Maltese say, "The stars twinkle; we cry 'wind.'"

Wind and Rain.

If the stars appear large and clear, expect rain or wind.

Thaw.

If shooting stars fall in the south in winter, there will be a thaw.

PROVERBS RELATING TO SNOW.

Animation.

Snow is generally preceded by a general animation of man and beast which continues until after the snow-fall ends.

Corn.

Corn is as comfortable under snow as an old man is under his fur cloak. (Russian.)

Christmas.

If it snows during Christmas night, the crops will do well.

So far as the sun shines on Christmas day,
So far will the snow blow in May. (German.)

Dry or Wet Snow.

When the snow falls dry it means to lie,
But flakes light and soft bring rain oft.

Ditch Snow.

When now in the ditch the snow doth lie,
'Tis waiting for more by and by.

Dry or Wet Snow.

If the snow that falls during the winter is dry and is blown about by the wind, a dry summer will follow; very damp snow indicates rain in the spring. (Apache Indians.)

First Snow.

There will be as many snow storms during the season as there are days remaining in the month after the time of the first snow.

When the first snow remains on the ground some time, in places not exposed to the sun, expect a hard winter.

Fast Snow.

The number of days the last snow remains on the ground indicates the number of snow storms which will occur during the following winter.

Heavy Snows.

Heavy snows in winter favor the crops of the following summer.

January Snow.

If there is no snow before January, there will be the more snow in March and April.

Leaves.

When dry leaves rattle on the trees, expect snow.

Light and Heavy Snow.

A heavy fall of snow indicates a good year for crops, and a light fall the reverse. (Dr. John Menaul.)

Mountain Snow.

If much snow be spread on the mountains in winter, the season of planting will be made blue with verdure. (Indian.)

March Snow.

In March much snow
To plants and trees much woe. (German.)

Mud.

When snow falls in the mud it remains all winter.

November.

A heavy November snow will last until April. (New England.)

If the snow remains on the trees in November, they will bring out but few buds in the spring. (German.)

Popping Wood.

Burning wood in winter pops more before snow.

Snow fertile.

Snow is the poor man's fertilizer, and good crops will follow a winter of heavy snowfall.

Snow trees.

If the first snow sticks to the trees, it foretells a bountiful harvest.

Snowball.

Cut a snowball in halves: if it is wet inside, the snow will pass off with rain; if it is dry inside, the snow will be melted by the sun.

Snow-flakes.

If the snow-flakes increase in size, a thaw will follow.

Snow-moon.

If a snow-storm begins when the moon is young, the rising of the moon will clear away the snow.

Snow-health.

The more snow the more healthy the season. (John Ayers, Santa Fé.)

Snow-year.

A snow year, a rich year.

As many days as the snow remains on the trees, just so many days will it remain on the ground.

It takes three cloudy days to bring a heavy snow. (New England.)

White Christmas.

A white Christmas, a lean graveyard.

Sleet.

Much sleet in winter will be followed by a good fruit year.

PROVERBS RELATING TO THE SUN.

Aurora.

Aurora borealis denotes cold.

If Aurora with half-open eyes
And a pale sickly cheek salutes the skies,
How shall the vines with tender leaves defend
Her teeming clusters when the storms descend.
(Virgil.)

Candlemas Day.

So far as the sun shines in on Candlemas day (2d of February)
So far the snow will blow in before the first of May.

Cloudy Sunset.

The sun sets weeping in the lowly west,
Witnessing storms to come woe and unrest.
(Shakespeare.)

When the sun sets unhappily (with a hazy veiled face) then will the morning be angry with wind, storm, and sand. (Zuñi Indians.)

Color.

Since the colors and duration of twilight, especially at evening, depend upon the amount of condensed vapor which the atmosphere contains, these appearances should afford some indications of the weather which may be expected to succeed. The following are some of the rules which are relied upon by seamen: When after sunset the western sky is of a whitish-yellow, and this tint extends a great height, it is probable that it will rain during the night or next day. Gaudy or unusual hues with hard, definitely outlined clouds, foretell rain and probably wind. If the sun before setting appears diffuse and of a brilliant white, it foretells storm. If it sets in a sky slightly purple, the atmosphere near the zenith being of a bright blue, we may rely upon fine weather.

Days.

As the days begin to shorten
The heat begins to scorch them.

Dark Clouds.

If the sun sets in dark, heavy clouds, expect rain next day.

If at sunrise there are many dark clouds seen in the west and remain there, rain will fall on that day.

Double Setting.

Sun setting double indicates much rain. Red sun indicates fair weather. Orange sun usually foul weather. Mock suns in winter are usually followed by intense cold.

Dull Color.

When the sun appears a pale or dull color, expect rain.

Drawing Water.

Rays of the sun appearing in a cloud forebode rain. This phenomenon is, in fact, caused by the image of the sun being reflected in an intervening cloud, the reflected image radiating in the cloud. It is noticed by Aristotle.

When the sun draws water, rain follows soon.

Sun drawing water indicates rain.
If the sun draws water in the morning, it will rain before night.

Easter.

If sun shines on Easter, it will shine on Whit Sunday.

Fiery Red.

In fiery red the sun doth rise,
Then wades through clouds to mount the skies.

Friday.

If the sun sets clear Friday evening, it will rain before Monday night.

Golden Set.

The weary sun hath made a golden set,
And by the bright track of his fiery car
Gives token of a goodly day to-morrow.
(Richard III.)

Halo.

When the sun is in his house (in a halo or circle) it will rain soon.
(Zuñi Indians.)

A solar halo indicates bad weather.

A halo around the sun indicates the approach of a storm, within three days, from the side which is the more brilliant.

If there be a ring or halo around the sun in bad weather, expect fine weather soon.

A bright circle around the sun denotes a storm, and cooler weather.

Haze.

Haze and western sky purple indicate fair weather.

Haziness.

A blur or haziness about the sun indicates a storm.

Hot Sun.

If the sun burn more than usual, or there be a halo around the sun in fine weather, "wet."

Looming Twilight.

Twilight looming indicates rain.

Low and High Dawn.

A low dawn indicates foul weather. A high dawn indicates wind.

Murky Clouds.

When the sun rises with dim, murky clouds, with black beams, clouds in the west, or appears red or green, expect rain.

Pale Twilight.

Pale, yellow twilight, extending high up, indicates threatening weather.

Pale Set.

If the sun sets pale, it will rain to-morrow.

Pale Sunrise.

If the sun rises pale, a pale red, or even dark blue, there will be rain during the day.

Pale Sunset.

A pale sunset, a golden sunset, or a green sunset, indicates rain.

Red Clouds.

If the clouds at sunrise be red, there will be rain the following day.

Red.

A red evening indicates fine weather; but if the red extends far upwards, especially in the morning, it indicates wind or rain.

Red Morn.

"A red morn: that ever yet betokened
Wreck to the seamen, tempest to the field,
Sorrow to shepherds, woe unto the birds,
Gust and foul flaws to herdsmen and to herds."
(Shakespeare: Venus and Adonis.)

Red Sky.

A very red sky in the east at sunset indicates stormy winds.

Red skies in the evening precede fine morrows.

In winter if the sun rises with a red sky, expect rain that day; in summer, expect showers and wind.

If the sun set with very red sky in the east, expect wind; in the southeast, expect rain.

Sun Spots.

Wet seasons occur in years when sun-spots are frequent.

Red Sun.

A red sun has water in his eye.

Scorching Sun.

When the sun in the morning (to 9 a. m.) is breaking through the clouds and scorching, a thunder-storm follows in the afternoon.

When the sun is scorching (*i. e.*, reflected from roofs and water surfaces), rain follows soon.

Sea-green Sky.

When the sky during rain is tinged with sea-green, the rain will increase; if with deep blue, the rain will be showery.

Spotted Clouds.

If the sun rises covered with a dark spotted cloud, expect rain on that day.

Spring.

If the sun appears dead, not bright and clear in the early spring, expect poor crops and very little rain. This sign usually comes in April. Dry winds may also be expected. (Apache Indians.)

Sun-dogs.

Sun-dogs indicate cold weather in winter or storm in summer.

A sun-dog at night is the sailor's delight;
A sun-dog in the morning is the sailor's warning.

Sunrise.

If de sun git up berry early and go to bed before he git up, it's a sign it rains before soon. (Negro.)

If the sun rises clear, then shadowed by a cloud, and comes out again clear, it will rain before night.

Sunshining Shower.

Sunshining shower won't last half an hour;
Sunshine and shower rain again to-morrow.

Ten and Two.

Between the hours of ten and two,
Will show you what the day will do.

Yellow Streaks.

Red or yellow streaks from west to east indicate rain in forty-eight hours.

Yellow Sunset.

A bright yellow sunset indicates wind; a pale yellow, wet; a neutral gray is a favorable sign in the morning, and unfavorable in the evening.

The sun rèveals the secrets of the sky,
And who dares give the source of light the lie.
(Virgil.)

PROVERBS RELATING TO THUNDER AND LIGHTNING.

Birds.

If the birds be silent, expect thunder.

Cattle.

If cattle run around and collect together in the meadows, expect thunder.

Christmas Thunder.

Thunder during Christmas week indicates that there will be much snow during the winter. (Kansas.)

Death—Plunder.

Winter thunder is to old folks death, and to young folks plunder.

Distant Thunder.

The distant thunder speaks of coming rain.

Early Thunder.

Early thunder, early spring.

Early and Late Thunder.

Thunder and lightning early in winter or late in fall indicates warm weather.

East Thunder.

If the first thunder is in the east, aha! the bear has stretched his right arm and comes forth, and the winter is over. (Zuñi Indians.)

East Wind.

If an east wind blows against a dark, heavy sky from the northwest, the wind decreasing in force as the clouds approach, expect thunder and lightning.

Evening Thunder.

If there be thunder in the evening, there will be much rain and showery weather.

Thunder in the evening indicates much rain.

Fall Thunder.

Thunder in the fall indicates a mild, open winter.

February Thunder.

Thunder and lightning in February or March, poor sugar (maple) year.

First Thunder.

The thunder-storms of the season will come from the direction of the first thunder-storm.

First thunder in winter or spring indicates rain and very cold weather. (Dr. John Menual.)

With the first thunder the gods of rain open their petals. (Zuñi.)

Forked Lightning.

Forked lightning at night,
The next day clear and bright.

Frogs and Snakes.

The first thunder of the year awakes the frogs and snakes from their winter sleep.

Heat.

Lightning brings heat.

July Thunder.

Much thunder in July injures wheat and barley.

Lightning without Thunder.

If there be lightning without thunder after a clear day, there will be a continuance of fair weather.

March Thunder.

Thunder in March betokens a fruitful year. (German.)

May Thunder.

If there is much thunder in May, the months of September and August will be without it.

Morning Thunder.

Morning thunder is followed by a rain the same day.

When it thunders in the morning, it will rain before night.

North Lightning.

Lightning in the North will be followed by rain in twenty-four hours.

Lightning in the North in summer is a sign of heat.

North—south.

Lightning in the North indicates rain in twenty-four hours. Lightning in the South low on the horizon indicates dry weather. (Kansas.)

North Star.

Lightning under North Star will bring rain in three days.

NW. Thunder.

Thunder-storm from NW. is followed by fine, bracing weather; but thunder and lightning from NE. indicates sultry, unsettled weather. (Observer at Santa Fé).

North Thunder.

Thunder in the north indicates cold weather and rain from the west.

If the first thunder is in the north, aha! the bear has stretched his left leg in his winter bed.

North Wind.

With a north wind it seldom thunders.

November Thunder.

Thunder and lightning on the northern lakes in November is an indication that the lakes will remain open until the middle of December or until Christmas. (Said to be reliable).

Red and Pale Lightning.

When the flashes of lightning appear very pale, it argues the air to be full of waterish meteors; and if red and fiery, inclining to winds and tempests.

September Thunder.

Thunder-storms in September mean plenty of snow in February and March, and a large crop of grape wine. (German).

If it thunders much at the beginning of September, much grain will be raised the following year.

Spring Lightning.

Lightning in spring indicates a good fruit year.

Spring Thunder.

If there be showery weather, with sunshine and increase of heat

in the spring, a thunder-storm may be expected every day, or at least every other day.

First thunder in the spring—if in the south it indicates a wet season, if in the north it indicates a dry season.

South or Southeast Thunder.

Thunder from the south or southeast indicates foul weather, from the north or northwest fair weather.

Sheet Lightning.

If there be sheet lightning with a clear sky on spring, summer, and autumn evenings, expect heavy rains.

South Thunder.

If the first thunder is in the south, aha! the bear has stretched his right leg in his winter bed. (Zuñi Indians.)

Summer Lightning.

Lightning in summer indicates good healthy weather.

West Thunder.

If the first thunder is in the west, aha! the bear has stretched his left arm in his winter bed. (Zuñi Indians.)

Winter Thunder.

A winter's thunder
Is a summer's wonder.

When thunder is heard in winter, it indicates cold weather. Thunder in the north indicates dry weather.

Thunder in winter means famine in summer.

Winter's thunder
Bodes summer hunger.

PROVERBS RELATING TO TREES.

Ash and Oak.

Ash before oak,
There'll be a smoke;
Oak before ash,
There'll be a smash.
(Meaning heat and wind.)

Dead Branches.

Dead branches falling in calm weather indicate rain.

Leaves.

Early falling leaves indicate an early fall.

Logs.

An easy-splitting log indicates rain.

Leaves.

Leaves turned up so as to show the underside indicate rain.

Maple.

When the leaves of the sugar-maple tree are turned upside down, expect rain.

PROVERBS RELATING TO WIND.

Aches and Pains.

As old sinners have all points
O' the compass in their joints,
Can by their pangs and aches find
All turns and changes of the wind.

Blast.

The sharper the blast,
The sooner 'tis past.

Barometer.

When the glass is low,
Look out for a blow;
When it rises high,
Let all your kites fly.

Backing Wind.

If the wind backs against the sun,
Trust it not, for back it will run.

Brisk Wind.

A brisk wind generally precedes rain.

Changing Wind.

It is a sign of continued fine weather when the wind changes during the day so as to follow the sun.

Winds changing from foul to fair during the night are not permanent.

Candlemas Day.

When the wind is on Candlemas day
There it will stick till the end of May.

Clear Sunset.

When the sun sets in a clear—
An easterly wind you need not fear.

Chenook Wind.

A Chenook wind is a warm wind which comes from the mouth of the Columbia river or Chenook Point. A Walla Walla wind is a cold wind which blows down the Columbia river. (Indian, North Pacific.)

Drought and Blast.

North and south the sign o' drouth,
East and west the sign o' blast.

East Wind.

In summer, if the wind changes to the east, expect cooler weather.

When the east wind toucheth it, it shall wither. (Ezekiel, chap. xvii, 10.)

And, behold, seven thin ears and blasted with the east wind came up. (Genesis, xli, 6.)

The east wind brought the locust. (Exodus, x, 13.)

God prepared a vehement east wind. (Jonah, chap. iv, 8.)

The east wind hath broken thee in the midst of the seas. (Ezekiel, chap. xvii, 26.)

An east wind brings no good to man or beast.

Easter Sunday.

As the wind blows on Easter Sunday from 8 a. m. to 12 m., the wind will be from that direction for the next forty days. (Chippewa Indians.)

Equinox.

The wind being north-northeast and east three days before the sun crosses the line, then southeast by way of east, then calm on the 23d, will bring enough and stormy winds from east and west all the winter.

East and West Wind.

When the wind is in the east,
The fish bite the least.
When the wind is in the west,
The fish bite the best.

Fixed East Wind.

If the wind becomes fixed in the east for the space of forty-eight hours, expect steady and continuous rain, with driving winds in the southwest during summer.

Gale.

A gale moderating at sunset will increase before midnight, but if it moderates after midnight, the weather will improve.

Fog and Mist.

Fog and mist raise higher seas than wind.

Heat.

If the wind be hushed with sudden heat, expect heavy rain.

Indiana Winds.

In Southern Indiana a southwest wind is said to bring rain in thirty-six hours.

Indian Proverbs Relating to Winds.

Wind from the north, cold and snow.

Wind from the western river of the northland, snow (northwest wind).

Wind from the world of waters, clouds (west wind).

Wind from the southern river of the world of waters, rain (southwest wind).

Wind from the land of the beautiful red, lovely odors and rain (south wind).

Wind from the wooded cañons, rain and moist clouds (southeast wind).

Wind from the land of day, it is the breath of health and brings the days of long life.

Winds from the lands of cold, the rain before which flees the harvest (northeast wind).

Winds from the lands of cold, the fruit of ice (northeast wind).

Wind from the right hand of the west is the breath of the god of sand clouds. (Zuñi Indians.)

Increasing Winds.

If the wind increases during a rain, fair weather may be expected soon.

Milk Cream.

Milk cream makes most freely with a north wind.

Northerly and Southerly Winds.

If the wind is from the northwest or southwest, the storm will be short; if from the northeast, it will be a hard one; if from the northwest, a cold one; and from the southwest a warm one. After it has been raining some time, a blue sky in the southeast indicates that there will be fair weather soon.

North Wind.

If there be within four, five, or six days two or three changes of wind from the north through without much rain and wind, and thence again through the west to the north with rain or wind, expect continued showery weather.

The north wind driveth away rain. (Proverbs, xxv, 23.)

Northeast Rain.

As a rule northeast rains indicate cold and damp soil, poor prospects for small seeds, melons, &c. (Apache Indians.)

North, East, South, and West Winds.

When the wind is in the north,
The skilful fisher goes not forth;
When the wind is in the east,
'Tis good for neither man nor beast;
When the wind is in the south,
It blows the flies in the fish's mouth;
But when the wind is in the west,
There it is the very best.

(Isaak Walton.)

Northeast Wind.

If the wind changes to the northeast or north, expect cold weather.

If there be northeast or east winds in the spring, after a strong increase of heat, and small clouds appear in the different parts of the sky, or if the wind changes from east to south at the appearance of clouds preceded by heat, expect heavy rains.

Northwest and East Winds.

When the wind is in the northwest
The weather is at its best;
But if the rain comes out of the east
'Twill rain twenty-four hours at least.

Northwest and Northeast Winds.

Northwest wind brings a short storm;
A northeast wind brings a long storm.

Northwest Winds.

Northwest wind brings only rain showers.

If there be a change of wind from the northwest or west to the southwest or south, or else from the northeast or east to the southeast or south, expect wet weather.

If the northwest or north winds blow with rain or snow during three or four days in the winter and then the wind passes to the south through the west, expect continued rain.

In summer if the wind changes to the northwest, expect cooler weather.

If a northwest wind shifts to northeast, remaining there two or three days without rain, and then shifts to the south, and then back to the northeast, with very little rain, fair weather may be expected during the following month. (Observer at Cape Mendocino.)

New Year's Eve.

If New Year's Eve night wind blow from south,
It betokeneth warmth and drouth;
If west, much milk, and fish in sea;
If north, much cold and storm there'll be;
If east, the trees will bear much fruit;
If north, flee it man and beast.

November—December.

As the wind is in the month of November, so will it be in the month of December.

No Wind.

No weather is ill
If the wind is still.

Night Winds.

Winds at night are always bright,
But winds in the morning, sailors take warning.

Pigs.

When pigs carry straws to their sty, a wind-storm may be expected.

Rising Wind.

First rise after very low
Indicates a strong blow.

Fast rise after a low
Precedes a stormy blow.

Rain-Wind.

Wind before a rain, set your topsails fair again.
Rain before the wind, keep your topsails snug as

South Wind.

When ye see the south wind blow, ye say there will be heat; and it cometh to pass. (Saint Luke, xii, 55.)

A wind in the south
Is in the rain's mouth.

The rain comes scuth
When the wind is in the south.

(Scotch.)

Brisk winds from the south for several days in Texas are generally followed by a "norther."

If there be dry weather with a light south wind for five or six days, it having previously blown strongly from the same direction, expect fine weather. (Texas.)

The southern wind doth blow a trumpet to his purpose, and by his hollow whistling in the leaves foretells a tempest and a blustering day. (Shakespeare.)

Southwest Wind.

In fall and winter if the wind holds a day or more in the southwest, a severe storm is coming; in summer, same of northeast wind.

A southwest blow on ye
And blister ye all over.

(Shakespeare.)

Three southwesters, then one heavy rain.

The third day of southwest wind will be a gale, and wind will veer to northwest between 1 and 2 a. m. (in winter) with increasing force. (From fisherman on North Carolina coast.)

If the wind shifts around to the south and southwest, expect warm weather.

Southeast Wind.

If the wind blows from the southeast during September 20th and 21st, the weather from the middle of February to the middle of March will be warm.

Shifting During Drought.

In Texas and the southwest when the wind shifts during a drought, expect rain.

September Winds.

If the wind blows from the south on the 21st of September, it indicates a warm autumn.

Sun.

Winds that change against the sun
Are always sure to backward run.

Storm.

When a heavy cloud comes up in the southwest and seems to settle back again, look out for a storm.

Wind-storms usually subside about sunset, but if they do not the storm will probably continue during the following day.

Always a calm before a storm.

Squalls.

Squalls making up on the flood-tide will culminate about high-water; those making on ebb-tide will culminate about low-water. (South Atlantic coast.)

West Wind.

Wind in the west, weather at the best.
Wind in the east, neither good for man or beast.

West Wind.

A west wind north about
Never hangs lang out.

(Scotch.)

West, East, South, and North Wind.

The west wind always brings wet weather,
The east wind cold and wet together,
The south wind surely brings us rain,
The north wind blows it back again.

(English.)

Veering Wind.

A veering wind indicates fair weather, a backing wind foul weather.

Unsteady Winds.

The whispering grove betrays the gathering elemental strife.
Unsteadiness of the wind is an indication of changeable weather.

Whirlwinds.

When numerous whirlwinds are observed, the rotation being opposite to that of the sun, look for wind and rain.

Weather.

Every wind has its weather.

White Clouds.

Heavy, white, rolling clouds in front of a storm denote high wind.

PROVERBS RELATING TO YEARS AND SEASONS.

Almond Blooms.

Mark well the flowering almonds in the wood;
If odorous blooms the bearing branches load,
The glebe will answer to the sylvan reign,
Great heats will follow and large crops of grain;
But if a wood of leaves o'ershades the tree
Such and so barren will the harvest be.

(Virgil.)

Autumn.

A pleasant autumn and a mild winter will cause the leaves to fall next September.

A moist autumn, with a mild winter, is followed by a cold and dry spring, retarding vegetation. If the summer be rainy the following winter will be severe.

Cherry Year.

A cherry year
A merry year.

Coat.

Who doffs his coat on winter's day
Will gladly put it on in May.

(Scotch.)

Cold Spring.

A cold spring kills the roses. (Arabia.)

Equinox.

As the wind and weather is at the time of the equinox, so will be the wind and weather generally during the following three months.

As clear off the line, or equinoctial storm, so will all storms clear for six months.

Fair.

One fair day in the winter does not make the birds merry.

Fall.

A wet fall indicates a cold and early winter.

Famine.

After a famine in the stall
Comes a famine in the hall.

Frosty Nights.

Frosty nights and hot summer days
Set the cornfields all in a blaze.

Harvest.

The harvest depends more on the year than on the field. (Denmark.)

Haw Year.

A haw year
A braw year.
(Ireland.)

A haw year
A snaw year.
(Scotland.)

Indian Summer.

If we don't get our Indian summer in October or November we will get it in winter.

Late Spring.

A late spring is a great blessing.

A late spring never deceives.

Long Harvest.

A long harvest, a little corn.

Leap Year.

In leap year the weather always changes on Friday.

Late Spring.

A late spring is bad for cattle, and an early spring for corn.

Nut—Corn.

A good nut year, a good corn year.

Oak Tree—Barley.

When the oak puts on his goslin grey
'Tis time to sow barley, night or day.

Old Year.

If the old year goes out like a lion the new year will come in like a lamb.

Pear—Dear.

A pear year
A dear year.

Plum.

In the year when plums flourish all else fails. (Devon.)

A plum year
A dumb year.

(Kent.)

Rainy Winter.

After a rainy winter follows a fruitful spring.

Seasons.

Extreme seasons occur from the 6th to the 10th year of each decade (especially in alternate decades).

A severe autumn denotes a windy summer;
A windy winter a rainy spring;
A rainy spring a severe summer;
A severe summer a windy autumn;
So that the air in balance is
Seldom debtor unto itself.

(Lord Bacon.)

Short Harvest.

Short harvests make short earnings. (Yorkshire.)

Sloe Tree.

When the sloe tree is as white as a sheet
Sow your barley, whether it be dry or wet.

Snow.

A snow year a rich year.

Sow Beans.

Sow beans in the mud,
And they'll grow like a wood.

Sow.

Sow thin, shear thin.

Spring Rain.

In spring a tub of rain makes a spoonful of mud;
In autumn a spoonful of rain makes a tub of mud.

Spring is both father and mother to us, and he who does not sow will not reap. (Gallicia.)

If the spring is cold and wet, the autumn will be hot and dry.

Fog in January makes a wet spring.

If it storms on February 2d, then the spring is not very far; but when bright and clear, then the spring will be late.

If it snows on February 2d, only as much as to be seen on a black ox, then summer will come soon.

When in February it is mild,
Brings the spring the frost by night.

If it does not rain on St. Michael's (29th of September) and Gallus (October 16th), the farmer will promise a dry spring.

Christmas in mud, Easter in snow.

If at Christmas ice hangs on the willow, clover may be cut at Easter.

Spring and Autumn Rain.

Spring rain damps; Autumn rain soaks. (Russia.)

Summer.

As much fog as plagues you in March, so many thunder-storms after one hundred days.

As much fog in March, so much rain in summer.

If it rains on June 27th, it will rain seven weeks.

As the weather on July 10th, so it will be for seven weeks.

When the sun enters "Leo" the greatest heat will then arise.

As the dog days commence so they end.

Midsummer rain
Spoils wine, stock, and grain.

Happy are the fields that receive summer rain.

Summer comes with a bound; winter comes yawning. (Finland.)

Summer in winter and summer's flood
Never boded an Englishman good.

The Year.

Do not abuse the year till it has passed. (Spain.)

Thunder.

Thunder in spring
Cold will bring.

Wet Spring.

A wet spring—a dry harvest.

Winter.

In winter expect not fair weather from one night's ice.

An early winter is surely winter.

Winter's back breaks about the middle of February.

He that drops a coat on a winter day
Will gladly put it on in May.

Winter will not come till the swamps are full. (South.)

When the days get longer, comes the winter.

If cold at St. Peter's day (February 22d), it will last longer.

The night of St. Peter's shows what weather we will have for the next forty days.

St. Matthew breaks the ice; if he finds none he'll make some.

After Matthew's no fox will run over the ice.

If on St. Michael's day the winds blow from the north and east, a cold winter may be expected.

Light rain on St. Michael's day is followed by a mild winter.

After a warm autumn a long winter.

When beech acorns thrive well and oak trees hang full, a hard winter will follow with much snow.

Much fog in autumn, much snow in winter.

If October brings much frost and wind, then are January and February mild.

Clear autumn, windy winter.

As many days from the first snow to the next new moon, so many times will it thaw during winter.

When birds and badgers are fat in October, a cold winter is expected.

If on All Saints' day the beech acorn is dry we will stick behind the stove in winter, but if it is wet and not light the winter will not be dry, but wet.

If it is at Martin (November 11th) fair, dry, and cold, the cold in winter will not last long.

If the geese at Martin's day stand on ice, they will walk in mud on Christmas.

If the leaves of the trees and grape-vines do not fall before Martin's day, a cold winter may be expected.

As November 21st, so the winter.

When in November the water rises, it will show itself the whole winter.

When the winter is not early it will not be late.

December changeable and mild,
The whole winter will remain a child.

Lengthened winter and tardy spring are both good for hay and grain, but bad for corn and garden.

Winter thunder and summer's flood
Never boded any good.

Winter finds what summer lays up.

Winter Thunder.

Poor man's death, rich man's hunger.

Winter Fire.

In winter a fire is better than a Muscat rose. (Persia.)

Year.

Wet and dry years come in triads.

A dry year never starves itself.

PROVERBS RELATING TO MONTHS, WEEKS, AND DAYS.

Month.

The month that comes in good will go out bad.

January.

If grass grows in January, it will grow badly the whole year.

In January if the sun appear,
March and April pay full dear.
(English.)

A January thaw is a sign for a July freshet.

If the grass grows green in January, it will grow the worse for it all the year.

In the Shepherd's Almanac for 1676, among the observations on the month of January we find the following: "Some say that if on the 12th of January the sun shines it foreshows much wind. Others predict by Saint Paul's day, saying if the sun shine it betokens a good year; if it rain or snow, indifferent; if misty it predicts great dearth; if it thunder, great winds and death of people that year."

A favorable January brings us a good year.

Fair on Saint Paul's conversion day (25th) is favorable to all fruits.

In January much rain and little snow is bad for mountains, valleys, and trees.

Saint Paul fair with sunshine,
Brings fertility to rye and wine.

Have rivers much water in January, then the autumn will forsake them. But are they small in January, then brings the autumn surely much wine.

Is January wet, remains empty the barrel.

If Saint Vincent's (22d) has sunshine,
One hopes much rye and wine.
If Saint Paul's (25th) is bright and clear,
One does hope a good year.

If on Saint Paul's it rains and snows, the grain will be costly.

Much rain in January, no blessing to the fruit.

Fruit that grows in January will generally be costly or dear.

January warm, the Lord have mercy.

January wet no wine you get.

Fog in January brings a wet spring.

Hoar frost and no snow is hurtful to fields, trees, and grain. If grain grows in January there will be a year of great need.

Dry January, plenty of wine. January 1st.—Morning red, foul weather, and great need. January 2d.—As the weather is this day so will it be in September.

If the grass grows green in January, it will grow the worse for it all the year.

January fill dyke,
February black and white.

A summerish January indicates a winterish spring.

Always expect a thaw in January.

A January spring is worth nothing.

A wet January, a wet spring.

February.

Double faced February.

Violent north winds in February herald a fertile year.

February 2d bright and clear
Gives a good flax year.

On Romanus (28th) bright and clear
Indicates a good year.

If the ground-hog is sunning himself on the 2d he will return for four weeks to his winter quarters again. St. Dorothea (the 6th) gives the most snow. When the cat in February lies in the sun, she will again creep behind the stove in March. When the north wind does not blow in February, it will surely come in March.

If February gives much snow
A fine summer it doth foreshow.

There is always one fine week in February.

Of all the months of the year, curse a fair February.

Heavy north winds in February forbode a fruitful year. (German.)

If on the 2d of February the goose finds it wet, then the sheep will have grass on March 25th.

When drops hang on the fence on the 2d of February, icicles will hang there on the 25th of March.

For every thunder with rain in February there will be a cold spell in May.

February rain is only good to fill ditches. (French.)

The nights of the 20th and 28th are called in Sweden "steel nights," on account of their cutting severity.

February makes a bridge and March breaks it.

February doth cut and shear,
February fill dike.
Be it black or be it white;
But if it be white
It's the better to like.

March.

Winds in March and rains in April promise great blessings in May. As much dew as shown in March so much fog rises in August.

In beginning or in end
March its gifts will send.

As it rains in March, so it rains in June.

Is't on Joseph's day (19th) clear,
So follows a fertile year;
Is't on Mary's (25th) bright and clear,
Fertile is said to be the year.

A damp, rotten March gives pain to farmers.

A dry March, wet April, and cool May
Fill barn, cellar, and bring much hay.
Rain in March, poor harvest.

Dust in March brings grass and foliage.

If it does not freeze on the 10th, a fertile year may be expected.

Snow in March is bad for fruit and grape vine.

March will search, April will try;
May will tell you whether you live or die.

March wet and windy,
Makes the barn full and findy.

March damp and warm,
Will do the farmer much harm.

March dust and March wind bleaches like a summer's sun. (Scotch.)

A peck of March dust and showers in May,
Make corn green and fields gray.

When March is like April, April will be like March.

If March comes in with adder's head,
It goes out with peacock tail.

A dusty March, a snowy February, a moist April, and a dry May, presage a good year. (French.)

A bushel of March dust is worth a king's ransom.

A windy March and a rainy April make a beautiful May.

A dry March never brings its bread.

March comes in like a lamb and goes out like a lion.

So many frosts in March, so many in May.

March wind and May sun
Make clothes white and maidens dun.

A March wisher
Is not a good fisher.

A windy March and a rainy April make a fine May.

March grass never did good.

March in January, January in March, I fear.

April.

Is't in April fair and mild,
The nill may be so much more wild.

Thunder-storm in April is the end of hoar frost. After a wet April follows a dry June. Whatever March does not want April brings along.

April and May are the keys of the year.

A cold April the barn will fill.

A dry April not the farmers will; rain in April is what he wills.

Snow in April is manure; snow in March devours.

April cold and wet fills barn and barrel.

At St. Gorgen (24th) the meadow turns into hay.

April snow breeds grass.

Moist April clear June.

Wet May, dry July. (German.)

When on St. George (24th) rye has grown so high as to hide a crow therein, a good harvest may be expected.

When April makes much noise
We will have plenty of rye and hay;
When April blows its horn
Then it stands good with hay, rye, and corn.

A cold and moist April fills the cellar and fattens the cow.

When April blows his horn
'Tis good for both hay and corn.

April showers
Bring May flowers.

April borrows three days from March, and they are ill.

May.

A dry May is followed by a wet June. A normal wet and cool May brings a wet June. An abnormal warm May brings a wet June.

Dry May brings nothing.

Many thunder-storms in May,
And the farmer sings hey! hey!

Rain in the beginning of May is said to be injurious to wine.

Cool and evening dew in May
Brings wine and much hay.

Hoar-frost on the 1st of May indicates a good harvest.

The later the black thorn in bloom after May 1, the better the rye and hay harvest.

If May will be a gardener, he will not fill the granaries.

Look at your corn in May,
And you'll come sorrowing away;
Look at it again in June,
And you'll come singing another tune.

A windy May makes a fair year. (Portuguese proverb.)

Water in May is bread all the year. (Spanish proverb.)

A hot May makes a fat churchyard.

A cold May enriches no one.

A May flood
Never did good.

A cold and windy May will fill the barn.

A dry May and a leaking June
Make the farmer whistle a merry tune.

May damp and cool fills the barns and wine-vats.

Mist in May and heat in June
Makes the harvest right soon.

(Scotch.)

Cast not a clout
Till May be out.

Be it early or be it late,
May will bring the corn quake.

A swarm of bees in May is worth a load of hay;
But a swarm in July ain't worth a fly.

If it rains on Philip's and Jacob's day (1st), a fertile year may be expected to follow.

Cold May brings many things.

A cold May and wind
Makes full barns and a findy.

(Scotch.)

June.

Rain on St. John's day (24th), and we may expect a wet harvest.

Previous to St. John's day we dare not praise barley.

If it rains on St. Peter's day (29th) the bakers will have to carry double flour and single water; if dry, they will carry single flour and double water.

Peter and Paul will rotten the roots of the rye.

O! St. Vitus (15th), O do not rain, so that we may not want barley.

A cold and wet June spoils mostly the whole year.

June, damp and warm, does not make the farmer poor.

Rain on St. Barnabas day is a good harvest in grapes.

Rain on St. John's (24th) will damage the nuts.

If north wind blows in June, rye will be splendid at harvest time.

When it is the hottest in June, it will be the coldest in the next February at corresponding days.

If St. Vitus day (15th of June) be rainy weather,
It will rain for thirty days together.

(Robin's Almanac, 1697.)

Calm weather in June
Sets corn in tune.

A dripping June
Brings all things in tune.

If on the 8th of June it rain,
It foretells wet harvests, men hath sain.

July.

If it rains on the 2d (St. Mary's), then it will rain the next four weeks.

As July, so the next January.

July, God send thee calm and fair,
That happy harvests we may see;
With quiet time and healthsome air,
And man to God may thankful be.

What July and August left undone in cooking, September will have undone in roasting. (German.)

If it rains on July 10th, it will rain for seven weeks.

Dog days bright and clear
Indicate a good year;
But when accompanied by rain,
We hope for better times in vain.

Whatever July and August do not boil, September cannot fry.

Clear on St. Jacob's day (20th) promises plenty fruit.

If three days previous to St. Jacob's are clear, then the rye will be good.

If the 1st of July be rainy weather,
'Twill rain more or less for three weeks together.

August.

Thunder-storms after Bartholomew's day are mostly violent.

When the dew is heavy in August the weather generally remains fair. When in beginning of August thunder-storms are passing, they will generally last to end of month.

As August, so the next February.

As Bartholomew day, so the whole autumn.

If the first week in August is unusually warm,
The winter will be white and long.

When the months of July, August, and September are unusually hot, January will be the coldest month.

On St. Mary's day (15th) sunshine
Brings much and good wine.

When in August the sun shines warm, moon and stars are bright; it is good for grapes, because they then ripen well.

Matthew's day (24th) bright and clear,
Brings good wine in next year.

A wet August never brings dearth. (Italian.)

When it rains in August it rains honey and wine.

If the 24th of August be fair or clear,
Then hope for a prosperous autumn that year.

Dry August, arid, warm,
Doth harvest no harm.

September.

As September, so the coming March.

September rain is much liked by the farmer.

Is the autumn warm, bright, and clear,
We may expect a fertile year.

When a cold spell occurs in September and passes without a frost, a frost will not occur until the same time in October.

Fair on the first of September, fair the entire month.

As the deer goes into the heat, so he will again step out.

As the weather on the 8th, so it will be for the next four weeks.

A wet September; next summer drouth, no crops and famine (California.)

If Michael brings many acorns, Christmas will cover the fields with snow.

September rain is good for crops and vines.

Thunder in September indicates a good crop of grain and fruit for next year.

If the storms in September clear off warm, all the storms of the following winter will be warm.

October.

Much rain in October, much wind in December.

If October brings heavy frosts and winds, then will January and February be mild.

When it freezes and snows in October, January will bring mild weather; but if it is thundering and heat-lightning, the winter will resemble April in temper.

Warm October, cold February.

As the weather in October, so will it be in the next March.

If the first snow falls on moist, soft earth, it indicates a small harvest; but if upon hard, frozen soil, a good harvest.

A good October and a good blast,
So blow the hog-acorn and the mast.

November.

As at Catharine (25th) foul or fair, so will be the next February.

As November, so the following March.

Thunder in November indicates a fertile year to come.

Flowers in bloom late in autumn indicate a bad winter.

November, take flail;
Let ships no more sail.

If there be ice in November that will bear a duck,
There will be nothing thereafter but sleet and muck.

December.

If it rains on Sunday before mass it will rain the whole week.

If Christmas finds a bridge, he'll break it; if he finds none, he'll make one.

As Ash Wednesday, so the fasting time.

A warm Christmas, a cold Easter.

A green Christmas, a white Easter.

If windy on Xmas day, trees will bring much fruit.

If the wind blows much on Stephen's day (26th), the grape will be bad in next year.

If it snows on Xmas night, we expect a good hop crop next year.

Christmas wet gives empty granary and barrel.

At Christmas meadows green, at Easter covered with frost.

Wet causes more damage than frost before, than after Christmas.

December cold, with snow, brings rye everywhere.

Days.

The first three days of any season rule the weather of that season.

The general character of the weather during the last twenty days of March, June, September, and December will rule the following season.

A bad day has a good night.

As the days lengthen,
So the cold strengthens.

The three days of September (20th, 21st, and 22d) rule the weather for October, November, and December.

The first three days of January rule the coming three months.

The last twelve days of January rule the weather of the whole year.

When there are three days cold, expect three days colder.

The twelve days commencing December 25th and ending January 5th are said to be the keys of the weather of the year.

Wednesday.

Wednesday clearing, clear till Sunday.

When the sun sets clear on Wednesday, expect clear weather the rest of the week.

Thursday.

The first Thursday in March, the first Thursday in June, the first Thursday in September, and the first Thursday in December are the governing days for each season. Whatever point of the compass the wind is on these days, that will be the prevailing direction of the wind for that season.

If it storms on the first Thursday, or any subsequent, of a month, count the remaining days of the month, add to this the number of days remaining of the moon, and they will give the number of storms for that season. (Wm. R. Ryan.)

Friday.

If the sun sets clear on Friday, it will blow before Sunday night.

If on Friday it rain,
'Twill on Sunday again;
If Friday be clear,
Have a Sunday no fear.

Rain on Good Friday forebodes a fruitful year.

Friday is the best or worst day of the week.

If the sun sets clear on Friday, generally expect rain before Monday.

A wet Good Friday and a wet Easter day,
Makes plenty of grass but very little hay.

As the Friday, so the Sunday.

Saturday.

There is never a Saturday without some sunshine.

Sunday.

If it rains on Sunday before mass it will rain all the week.

When it storms on the first Sunday of the month it will storm every Sunday.

First Sunday in month rain, it will rain every Sunday of the month.

Sunday clearing, clear till Wednesday.

The last Sunday of the month indicates the weather of the next month.

If sunset on Sunday is cloudy, it will rain before Wednesday.

Christmas.

A light Christmas, a heavy sheaf.

If the sun shines through the apple tree on Christmas day, there will be an abundant crop the following year.

If on Christmas night the wine ferments heavily in the barrels, a good wine year is to follow. (German.)

The shepherd would rather see his wife enter the stable on Christmas day than the sun. (German.)

If ice will bear a man before Christmas, it will not bear a mouse afterward. (English proverb.)

If Christmas day on Thursday be,
A windy winter you shall see.
Windy weather in each week,
And hard tempests strong and thick.
The summer shall be good and dry,
Corn and beast shall multiply.
(Copied from old MS.)

A green Christmas makes a full graveyard.

A green Christmas indicates a white Easter.

Candlemas Day.

If Candlemas day be fair and clear,
There'll be two winters in that one year.

On Candlemas day the bear, badger, or woodchuck comes out to see his shadow at noon; if he does not see it he remains out; but if he does see it he goes back to his hole for six weeks, and cold weather continues six weeks longer.

Have on Candlemas day
One-half your straw and one-half your hay.

Candlemas day if it be fair
The half of the winter 's to come and mair.
Candlemas day, if it be foul,
The half of winter 's past at yule.

On Candlemas day
Throw the candle and stick away.
When Candlemas is come and gone
The coal lies on a red-hot stove.

Just half your wood and half your hay
Should be remaining on Candlemas day.

If Candlemas day be fair and bright,
Winter will have another flight;
But if Candlemas day be clouds and rain,
Winter is gone and will not come again.

On Candlemas day just so far as the sun shines in, just so far will the snow blow in.

I would rather see my wife on a bier
Than to see Candlemas clear.

Corpus Christi.

Corpus Christi day clear
Gives a good year.

If rain on Corpus Christi day, the rye granary will be light.

Dog Day.

Rain on first dog day, it will rain for forty days after.

Easter.

Rain on Easter gives slim fodder.

If fair weather from Easter to Whitsuntide, the butter will be cheap.

Easter in snow, Christmas in mud;
Christmas in snow, Easter in mud.

Good Friday.

Good Friday rain brings a fertile year.

Hollantide.

If ducks do slide at Hollantide,
At Christmas day they'll swim;
If ducks do swim at Hollantide,
At Christmas day they'll slide.

Lent.

Dry Lent, fertile year.

Martinmas.

If the wind is in the southwest at Martinmas, it keeps there until Candlemas. (French.)

Pentecost.

Rain at Pentecost forebodes evil.

Paster Sunday.

If it rains on Paster Sunday, it will rain every Sunday until Pentecost.

Palm Sunday.

If the weather is not clear on Palm Sunday, it means a bad year.

Shrovetide Day.

When the sun is shining on Shrovetide day, it is meant well for rye and peas.

Saint Andrew's Day.

On Saint Andrew's night a glass of water should be placed on the table. If the water has run over in the morning, a good year is to follow; if it does not, expect a poor year for crops. (German.)

Saint Bartholomew.

If it rains on Saint Bartholomew's day (August 24th) it will rain forty days after.

Saint Bartholomew brings cold and dew. (Italian.)

Saint John's Day.

Before Saint John's day (24th of June) no early crops are worth praising. (German.)

Before Saint John's day we pray for rain; after that we get it anyhow.

Saint Lawrence Day.

If on Saint Lawrence day (August 10th) the weather be fine, a good autumn and good wine may be hoped for. (German.)

Saint Margaret's Day.

Rain on Saint Margaret's day (22d of July) will destroy all kinds of nut. (German.)

Saint Matthew's Day.

If it freezes on Saint Matthew's day, it will freeze for a month together.

Matthew's day (February 25th) breaks the ice; if he finds none, then he'll have some.

Saint Martin's Day.

Saint Martin's day (11th of November) if the wind is in the south-west at Martinmas, it keeps there till after Candlemas. (Scotch.)

Saint Paul's Day.

If Saint Paul's day is fair and clear,
It does betide a happy year.

If Saint Paul's be fair and clear,
It promises a happy year;
But if it chances to snow or rain,
There will be dear all sorts of grain;
Or if the wind does blow aloft,
Great stirs will vex the world full oft;
And if dark clouds do muff the sky,
The fowl and cattle oft will die.

If Saint Paul's day (25th January) be fair and clear,
It does betide a happy year;
But if it chance to snow or rain,
There will be dear all kinds of grain.
If clouds or mist do dark the sky,
Great store of birds and beasts shall die;
And if the winds do fly aloft,
Then war shall vex the kingdom oft.
(Old English.)

Upon Saint Paul's day
Put oats and barley in the clay.

Saint Patrick's Day.

Saint Patrick's day the warm side of a stone turns up, and the broad-back goose begins to lay.

Saint Stephen's Day.

If it be very windy on Saint Stephen's day, there will be a poor wine crop next year. (German.)

Saint Swithin.

A rainy Saint Swithin is well described by Gay:

Now on Saint Swithin's feast the welkin lours,
And every pent house streams with hasty showers;
But when the swinging signs your ears offend
With creaking noise, then rainy floods impend;
Soon shall the kennels swell with rapid streams,
And rush in muddy torrents to the Thames.

All Saints' Day.

If All Saints' day will bring out the winter, Saint Martin's day will bring out Indian summer.

All Fools' Day.

If it thunders on All Fools' day,
'Twill bring good crops of corn and hay.

Ascension Day.

As the weather on Ascension day, so may be the entire autumn.

Saint Thomas's Day.

Look at the weathercock on Saint Thomas day, at 12 o'clock, and see which way the wind is, for there it will stick for the next quarter.

Saint Vincent's.

If the sun shines on Saint Vincent's day (22 January), a fine crop of grapes may be expected. (German.)

Whit Sunday.

If Whit Sunday brings rain, we expect many a plague.

Whitsuntide.

Whitsuntide rain, blessing for wine.

Rain on Whitsuntide is said to make the wheat mildew.

Strawberries at Whitsuntide indicate good wine.

Whit Sunday bright and clear
Will bring a fertile year.

Whit Sunday wet, Christmas fat.

GENERAL PROGNOSTICS.

Some of the various signs of coming rain, which will be found in their respective places, are thus recorded by Swift:

Careful observes may foretell the hour
By sure prognostics when to dread a shower.
While rain depends, the pensive cat gives o'er
Her frolics and pursues her tail no more;
Returning home at night you'll find the sink
Strike your offended sense with double stink.

If you be wise, then go not far to dine,
You'll spend in coach-hire more than save in wine.
A coming shower your shooting corns presage,
Old aches will throb your hollow tooth with rage.

Sauntering in coffee-house is Dulman seen;
He damns the climate and complains of spleen.
Meanwhile the South, rising with dabbled wings,
A sable cloud athwart the welkin flings,
That swilled more liquor than it could contain,
And, like a drunkard, gives it up again.
Brisk Susan whips her linen from the rope,
While the first drizzling shower is borne aslope.
Such is that sprinkling which some careless quean
Flirts on you from her mop, but not so clean.
You fly, invoke the gods; then, turning, stop
To rail; she singing still, whirls on her mop.
Not yet the dust had shunned the unequal strife,
But, aided by the wind, fought still for life,
And wafted with its foe by violent gusts,
'Twas doubtful which was rain and which was dust.
Ah! where must needy poet seek for aid
When dust and rain at once his coat invade?
Sole coat; where dust, cemented by the rain,
Erects the nap and leaves a cloudy stain.

Another author observes of a wet Saint Swithin:

Twice twenty days shall clouds their fleeces drain,
And wash the pavements with incessant rain.
Let not such vulgar tales debase thy mind;
Nor Paul nor Swithin rule the clouds and wind.
If you the precept of the Muse despise,
And slight the faithful warnings of the skies,
Others you'll see, when all the town's afloat,
Wrapt in the embraces of a kersey coat
Or doubled-bottom frieze; their guarded feet
Defy the muddy dangers of the street,
While, with hat unlooped, the fury dread
Of spouts high streaming, and with cautious tread
Shun every dashing pool, or idly stop
To seek the kind protection of a shop.
But business summons; now with hasty scud
You jostle for the wall; the spattered mud
Hides all thy hose behind; in vain you scour.
Thy wig, alas! uncurled, admits the shower.
So fierce Electos' snaky tresses fell

When Orpheus charmed the rigorous powers of hell;
Or thus hung Glaucus' beard, with briny dew
Clotted and straight, when first his amorous view
Surprised the bathing fair. The frightened maid
Now stands a rock, transformed by Circe's aid.
And now sharp hail falls down in hasty sallies,
And all the tiles with dancing showers rattle,
And the fair Jewess hies to sheltered alleys
To sell her strawberries in brimful pottle,
And farmers praise Saint Swithin come again
To wet the crops with forty days of rain.

Air Currents.

Currents of air change their course frequently, in the higher regions of the air first, and are afterwards continued to the earth's surface; whence we can often foresee a change of wind by observing the clouds. Both the strength of a coming gale and the point from which it will blow may usually be determined by noticing the velocity and direction of the clouds floating along in the upper currents.

Appetite.

When everything is eaten at the table, it indicates continued clear weather.

Aurora.

The aurora when very bright indicates approaching storm.

Barometer.

If it freezes and the barometer falls two or three tenths of an inch, expect a thaw.

If the weather gets warmer while the barometer is high and the wind northeasterly, we may look for a sudden shift of wind to the south. On the other hand, if the weather becomes colder while the wind is southwesterly and the barometer low, we may look for a sudden squall or a severe storm from the northwest, with a fall of snow if it be winter time.

A sudden rise of the barometer is very nearly as dangerous as a sudden fall, because it shows that the level is unsteady. In an ordinary gale the wind often blows hardest when the barometer is just beginning to rise, directly after having been very low.

A rapid rise of barometer indicates unsettled weather. A slow movement the contrary, as likewise a steady barometer, which, when continued, and with dryness, foretells very fine weather.

Bells.

Bells are heard at greater distances before rain.

Boots and Shoes.

Boots and shoes easy to pull on and off indicate dry weather.

Brick Walls.

Brick walls become damp before a rain.

Breeders.

Fine, warm days are called "weather breeders."

Calm.

A dead calm often precedes a violent gale, and sometimes the calmest and clearest mornings in certain seasons are followed by a blowing, showery day. Calms are forerunners of the hurricanes of the West Indies and other tropical climes.

Camphor Gum.

Camphor gum is said to rise in alcohol before rain.

Clouds.

If clouds drive up high from the south, expect a thaw.

Coals.

Coals covered with thick white ashes indicate snow in winter and rain in summer.

Coals becoming alternately bright and dim indicate approaching storms.

Coffee Bubbles.

When the bubbles of coffee collect in the centre of the cup, expect fair weather. When they adhere to the cup, forming a ring, expect rain. If the bubbles separate without assuming any fixed position, expect changeable weather.

Corns.

Corns giving trouble indicate bad weather.

When corns ache rain follows.

Cream and Milk.

Cream and milk, when they turn sour in the night, often indicate thereby that thunder-storms are about, and will probably shortly take place.

Creeks and Springs.

In dry weather, when creeks and springs that have gone dry become moist, or, as we may say, begin to sweat, it indicates approaching rain. Many springs that have gone dry will give a good flow of water just before rain. (J. E. Walter, Leavenworth, Kans.)

Dandelion.

When the dandelions bloom early in the spring there will be a short season. When they bloom late expect a dry summer.

Dreams.

Dreams of a hurrying and frightful nature and imperfect sleep, are frequent indications that the weather is changed or about to change. Many persons experience these nocturnal symptoms on a change of wind, particularly when it becomes east. In all these cases the effect seems to be produced immediately on the nervous system, and through it on the stomach, so that the stomach shall again react on the sensorium. The symptoms are enhanced by a full stomach and other sources of indigestion. (Forster.)

Dust.

Dust rising in dry weather is a sign of approaching change.

Ears.

Ringing in the ear at night indicates a change of wind.

Ears, when there is a tingling noise, or what is called a singing in them, afford thereby a sign of a change of weather, not simply

of rain, as has been said, but of barometrical pressure in general. The sudden increase of pressure, like the descent from high mountains, or from balloons, causes in many persons a temporary deafness and roaring in the ears. A sudden fall of the barometer affects also the ears, but in a different manner, like mounting a high hill. (Forster.)

Noises in the ears are frequently precursors of marked atmospheric changes.

Eclipse Weather.

Eclipse weather is a popular term in the south of England for the weather following an eclipse of the sun or moon, and it is vulgarly esteemed tempestuous and not to be depended on by the husbandman.

Epidemics.

Epidemics are disorders of health brought on by atmospherical influence; and modern discoveries have shown how much most prevailing diseases partake of an epidemical nature. Scarlet fever, typhus, the plague, and indeed most diseases of this sort, are now considered epidemical. It would seem that there is a most immediate connection between the peculiar state of the air and the kind of disorders which might be thereby excited. For it may be observed that, even of those disorders which are not generally admitted to be contagious, one particular kind will prevail for a long time. Thus, in winter, the different symptoms of that state of body which we call a cold, appear in some measure to prevail and vary together, so that it is common to hear people talk of the fashionable complaint. Coughs, for a while, are the prevailing symptoms; then sore throats are the most common. It is in spring that certain kinds of cutaneous eruptions usually appear, and in autumn that those irregularities in the functions of the digestive viscera called cholera morbus, &c., happen, and which have been erroneously attributed to eating much fruit. On the other hand, it cannot be considered that atmospheric peculiarities alone produce epidemic and other complaints, which must be regarded as having a compound origin, and as resulting from the operation of peculiar states of the atmosphere on persons of particular states of constitution, otherwise all persons would be affected, which is contrary to experience. There are, probably, innumerable varieties of temperament, of general habits of life, and of pre-existing diseases, which in different subjects vary the effects of the air. And many persons perhaps enjoy a state of health and perfect action, which may be capable of resisting its evil influence altogether. It would perhaps be productive of useful results, if physicians of extensive practice would make accurate meteorological registers during the prevalence of any epidemic or contagious disorders. (Forster's Encyclopædia of Natural Phenomena.)

Epizootic.

Epizootic is a name for epidemic disorders occurring among animals, of which we have many and various instances on record. The state of the electrometer and other meteorological instruments should be carefully examined during the prevalence of such pestilence.

Elder Bush.

A number of superstitions may be traced back to the former connection of the elder bush with the goddess. Witches were thought to produce bad weather by stirring water with branches of elder.

Electric Lights.

Last night I saw St. Elmo's stars,
With their glimmering lanterns all at play
On the tops of the masts and the tips of the spars,
And I knew we should have foul weather that day.

Fire.

If the fire burns unusually fierce and bright in winter, there will be frost and clear weather; if the fire burns dull, expect damp and rain.

Fire always burns brighter and throws out more heat just before a storm, and is hotter during a storm.

Blacksmiths always select a stormy day in which to perform work requiring extra heat.

A fire hard to kindle indicates bad weather.

When the fire crackles and crackles lightly, it is said to be treading snow. (Old woman.)

Floors.

Floors saturated with oil become very damp just before rain.

Fog Smoke.

When with hanging fog smoke rises vertically, rain follows.

Gale.

If, during the absence of wind, the surface of the sea becomes agitated by a long, rolling swell, a gale may be expected. This is well known to seamen.

General.

But the best sign of all
If soot down the chimney fall.
The dog long asleep so sound,
We know moisture is in the ground.
The guinea at night groans so loud;
It says the rain is in the cloud.
The peacock appears on the scene,
And, with its spots both black and green,
Flies up to roost and screams so shrill,
He is heard o'er all the hill,
Saying that the sun is set;
In the morning we will be wet.
Old master sits and look with sorrow
On the prospect of the morrow.
Other signs just as good
Come from the vermin of the wood.
The owls hollow, the children scare,
Thus he tells when the rain is near.
If you kill the snake and hang it up,
You will find this is good luck;
And this will always bring the rain
To people who are not profane.
The gnats bite and I scratch in vain,
Because they know it is going to rain.
The cat, with her silken paws,
Washing there her whiskered jaws.

When these signs together come,
Nigger, you had better be at home.

(Negro.)

The cow looks up, and from afar can find
The change of heaven, and muffs it in the wind.
The swallow skims the river's watery face;
The frogs renew the croaks of their loquacious race.
The careful ant her secret cell forsakes,
And drags her eggs along the narrow tracks.
At either horn the rainbow drinks the flood;
Huge flocks of rising rooks forsake their food,
And, crying, seek the shelter of the wood.
Above the rest the sun, who never lies,
Foretells the change of weather in the skies;
For if he rise unwillingly to his race,
Cloud on his brow and spots upon his face;
Or if through mist he shoots his sullen beams,
Frugal of light in loose and struggling streams,
Suspect a drizzling day; * * *
If fiery red his glowing globe descends,
High winds and furious tempests he portends;
But if his checks are swollen with livid blue,
He bodes wet weather by his watery hue;
If dusky spots are varied on his brow,
And streaked with red a troubled color show,
That shallow mixture shall at once declare,
Winds, rain, and storms, and elements at war.

(Virgil.)

DR. JANNER'S REASONS FOR NOT GOING HUNTING.

[From "Weather Folk-Lore," by Rev. C. Swainson, M. A.]

Wind.

The hollow winds begin to blow,

Clouds—Barometer.

The clouds look black, the glass is low,

Soot—Dogs.

The soot falls down, the spaniels sleep,

Spiders.

And spiders from their cobwebs peep.

Sun.

Last night the sun went pale to bed,

Moon.

The Moon in halos hid her head.
The boding shepherd heaves a sigh,

Rainbow.

For, see! a rainbow spans the sky,

Walls—Ditches.

The walls are damp, the ditches smell,

Pimpernel.

Closed is the pink-eyed pimpernel.

Chairs and Tables.

Hark! how the chairs and tables crack;

Joints.

Old Betty's joints are on the rack.

Ducks.

Loud quack the ducks, the peacocks cry,

Hills.

The distant hills are looking nigh.

Swine.

How restless are the snorting swine!

Flies.

The busy flies disturb the kine,

Swallow.

Low o'er the grass the swallow wings;

Cricket.

The cricket, too, how sharp he sings;

Cat.

Puss on the hearth, with velvet paws,
Sits wiping o'er her whiskered jaws;

Fish.

Through the clear streams the fishes rise,
And nimbly catch the incautious flies;

Glowworm.

The glowworms, numerous and bright,
Illumed the gloomy dell last night;

Toad.

At dusk the squalid toad was seen
Hopping and crawling o'er the green.

Dust.

The whirling dust the wind obeys,
And in the rapid eddy plays;

Frog.

The frog has changed his yellow vest,
And in a russet coat is dressed.

Air.

Though June, the air is cold and still,

Blackbird.

The mellow blackbird's voice is shrill;

Dog.

My dog, so altered in his taste,
Quits mutton-bones on grass to feast;

Rooks.

And see yon rooks, how odd their flight,
They imitate the gliding kite,
And seem precipitate to fall
As if they felt the piercing ball.
'Twill surely rain; I see, with sorrow,
Our jaunt must be put off to-morrow.

(Dr. Janner.)

Wind.

Ere the rising winds begin to roar,

Sea.

The working seas advance to wash the shore;

Trees.

Soft whispers run along the leafy woods,

Mountains.

And mountains whistle to the murmuring floods.

Waves.

E'en then the doubtful billows scarce abstain
From the tossed vessel on the troubled main

Cormorants.

When crying cormorants forsake the sea
And, stretching, to the covert wing their way;

Coots.

When sportful coots run skimming o'er the strand;

Herons.

When watchful herons leave their watery strand,
And mounting upwards, with erected flight,
Gain on the skies and soar above the sight;

Meteors.

And oft before tempestuous winds arise
The seeming stars fall headlong from the skies,
And, shooting through the darkness, gild the night
With sweeping glories and long trains of light;

Chaff.

And chaff with eddy winds is whirled around,

Leaves.

And dancing leaves are lifted from the ground,

Feathers.

And floating feathers on the waters play;

Thunder.

But when the winged thunder takes his way
From the cold north, and east and west engage,
And at their frontiers meet with equal rage,
The clouds are crushed; a glut of gathered rain
The hollow ditches fills and floats the plain,
And sailors furl their dripping sheets amain.

Rain.

Wet weather seldom hurts the most unwise—
So plain the signs, such prophets are the skies;

Crane.

The wary crane foresees it first, and sails
Above the storm and leaves the lowly vales;

Cow.

The cow looks up, and from afar can find
The change of heaven, and snuffs it in the wind;

Swallow.

The swallow skims the river's watery face;

Frogs.

The frogs renew the croaks of their loquacious race;

Ant.

The careful ant her secret cell forsakes,
And drags her eggs along the narrow tracks.

Rainbow.

At either horn the rainbow drinks the flood.

Rooks.

Huge flocks of rising rooks forsake their food,
And, crying, seek the shelter of the wood.

Water-fowl.

Besides the several sorts of watery fowls
That swin the seas or haunt the standing pools,

Swans.

The swans that sail along the silvery floods,
And dive with stretching necks to search their food,
Then lave their backs with sprinkling dews in vain,
And stem the stream to meet the promised rain;

Crow.

The crow, with clamorous cries, the shower demands,
And single stalks along the desert sands;

Stars.

The stars shine smarter, and the moon adorns

Moon.

As with inborrowed beams her sharpened horns;

Gossamer.

The filmy gossamer now flits no more,

Halcyons.

Nor halcyons bask on the short sunny shore;

Swine.

Their litter is not tossed by sows unclean,

Mist.

But a blue, droughty mist descends upon the plain,

Owls.

And owls that mark the setting sun declare
A starlight evening and a morning fair.

Hawk and Lark.

Towering aloft, avenging Nisus flies,
While dared below the guilty Scylla lies;
Wherever frightened Scylla flies away
Swift Nisus follows and pursues his prey;
Where injured Nisus takes his airy course,
Then trembling Scylla flies and shuns his course.
This punishment pursues the unhappy maid,
And thus the purple hair is dearly paid.

Ravens.

Then thrice the ravens rend the liquid air,
And croaking notes proclaim the settled fair;
Then 'round their airy palaces they fly
To greet the sun; and, seized with secret joy,
When storms are overblown, with food repair
To their forsaken nests and callow care.
Not that I think their breasts with heavenly souls
Inspired, as man who destiny controls;
But, with the changeful temper of the skies,
As rains condense and sunshine rarefies,
So turn the species in their altered minds,
Composed by calms and discomposed by winds.

Birds.

From hence proceeds the bird's harmonious voice,

Cows and Lambs.

From hence the cows exult and frisking lambs rejoice.
(Virgil.)

Goose-bone.

When the goose-bone exposed to air turns blue, it indicates rain.

When the goose-bone exposed to air retains its color, expect clear weather.

Gossamer.

In crossing the channel from Calais to Dover, I have observed that captains of vessels have sometimes foreboded fine settled weather from the settling on the masts and rigging of a certain sort of web which we take to be the woof of some spider, though we have observed it to alight on the ships when some way out at sea. (Forster.)

Guitar Strings.

Guitar strings shorten before rain.

Headaches.

Headaches often indicate a change of weather in persons subject to such complaints. Indeed, most periodical disorders seem to be connected with some atmospheric changes. And it is very remarkable that they should so often have their worst paroxysms and the crisis of their terms about the time of the conjunction and the apposition of the moon. (Forster.)

Hills.

Distant hills appear to be near just before rain.

Horses.

Horses sweating in the stable is a sign of rain.

Human Hair.

Human hair (red) curls and kinks at the approach of a storm and restraightens after the storm.

Indications of Clouds.

After fine weather the first signs in the sky of a coming change are usually light streaks, curls, wisps, or mottled patches of white distant clouds, which increase and are followed by an overcasting or murky vapor that grows into cloudiness.

Lamp Wicks.

Lamp wicks crackle, candles burn dim, soot falls down, smoke descends, walls and pavements are damp, and disagreeable odors arise from ditches and gutters before rain.

Excrescence forming about wicks of lamps and candles, which consume their fuel slowly, indicate rain.

> The nightly virgin while her wheel she plies
> Foresees the storm impending in the skies
> When sparkling lamps their sputtering lights advance,
> And in their sockets oily bubbles dance.

Lamps, from the manner in which they burn, forebode weather. Before rain they burn less bright, the flame snaps and crackles, and a sort of fungous excrescence grows from the wicks, which Virgil was mindful to put among his prognostics of rain and wind. From this indicatorial property of the burning lights arose many superstitions relating to them, as the blue color of the flame being a sign of ghost and death, and so on, of which the following explanation is already offered in the Perennial Calendar:

"Numerous were the omens attached by credulous persons in former days to the manner in which candles burnt, and particularly to their flames. When they burned blue, it was accounted ill luck, or else that some ghostly apparition was announced. Now when the brain and nervous system are in a certain state peculiarly favorable to spectral illusions, the imagination may easily color the flame of a candle, without its really changing its tint; just as, in fevers, people see spots of color on the wall, or imagine insects on the bed-clothes. For the same morbid condition of the animal system which may cause persons to see the spectral prognostic, would in this case cause them to behold the subsequent phantom, and thus the omen and its awful consequence would be viewed together to the support of superstition. Besides this, the particular mode of burning observed in the wicks of lamps and candles is really found to be caused by atmospherical peculiarities, and is a sure sign of rain." (Forster's Encyclopædia of Natural Phenomena.)

Light.

Refractions of light of any remarkable kind frequently forebode rain, sometimes storms; at sea the knowledge of this is very useful. Circles around the sun and moon, mock suns, and other phenomena of this kind, together with the unusual elevation of distant coasts, masts of ships, &c., particularly when the refracted images are inverted, are known to be frequent foreboders of stormy weather.

Long Island.

When Long Island comes up the harbor, expect a storm. (Connecticut.)

Lumen Lambens.

Lumen Lambens is an electric light seen about plants of a summer evening, of which the particular indications as to the coming weather have not been yet accurately discovered.

Matting.

The matting on the floor is shrinking, dry weather may be expected. When matting expands, expect wet weather.

Marigold.

When the marigold remains closed after 7 p. m., expect rain.

Night Clearing.

After a wet day the whole sky often clears at night. This is not a certain sign of fair weather. The clouds may, and often do, form just as heavily after sunrise next morning.

Oak Trees.

When oak trees bend in January, good crops may be expected.

Ocean.

There are various prognostics deducible from the appearance of the ocean. When the surface of the sea is rough without any wind blowing at the time, expect a gale before long; for the wind already blowing in some distant part of the ocean is the cause of the swell imparted to the sea.

Pavements.

If pavements appear rusty or if stoves or iron or steel rust during the night, rain may be expected soon.

Pipes.

Pipes for smoking tobacco become indicative of the state of the air. When the scent is longer retained than usual, and seems denser and more powerful, it often forebodes rain and wind.

Rain.

The greater distinctness of distant objects indicates rain. The air grows clear and distant objects are seen more clearly just before rain.

Rigging Rope.

The rigging rope on vessels and clothes lines grows slack before rain.

Rheumatic.

Rheumatic pains indicate bad weather.

Rocks.

Rocks sweat before rain.

Ropes.

Ropes difficult to untwist indicate bad weather.

Salt.

Saline impregnations deliquesce before rain. Salts become damp before rain.

Shifts of Wind.

The most dangerous shifts of wind or the heaviest northerly gales happen soon after the barometer first rises from a very low point, or, if the wind veers gradually, at some time afterwards.

Smoke.

Smoke frequently indicates the state of the air. A person being accustomed to take his pipe early in the morning will have occasion to observe that when the smoke hangs a long while in the air, and scents the place around where he has been smoking, a good hunting day always follows. (Forster.)

Smoke falling to the ground indicates rain.

Smoke ascending indicates clear weather.

When smoke rises from the bottom lands and goes to the mountain, expect an early winter. (Apache Indians.)

When the sun presses the smoke out of chimneys, foul weather follows.

When the smoke in clear weather rises vertically from the chimney, the weather will remain clear.

Snow.

If snow falls in flakes which increase in size, expect a thaw.

Soap.

Soap covered with moisture indicates bad weather.

Soot.

When in cold weather the soot falls from the chimney, the weather will change.

Falling soot indicates bad weather.

Soot burning on back of chimney indicates storms.

When the soot on pots over the fire sparkles, rain follows.

Sound.

Sound travelling far and wide
A stormy day will betide.

When on calm days the sound is carried far, rain follows.

Sounds.

Distant sounds heard with distinctness during the day indicate rain.

Stones.

Quarries of stone and slate indicate rain by a moist exudation from the stones. This seems analogous to the dampness on stones, stone steps, and ornaments, both of stone and of metal, before rain and in damp weather.

Stones sweating in the afternoon, the springs running flusher (commonly called earth sweat), such are atmospheric indications of rain.

Stringed Instruments.

Stringed instruments giving forth clear, ringing sounds indicate fair weather.

Storm.

It moderates to storm.

Stomach.

This organ in persons of weak and irritable constitutions is often deranged at the change of the weather, and its digestive powers are more under atmospherical influence than people are commonly aware of. Before storms it is particularly liable to uneasy sensations.

Sweating Stones.

A sweating stone indicates rain.

Sweating Wall.

A sweating wall indicates rain.

Tables and Chairs.

The cracking of tables and chairs indicates rain or frost.

Thunder.

Abundance depends upon sour milk; meaning that thunder-storms aid crops.

Thunder-storms almost always occur when the weather is hot for the season; they are generally caused by a cold wind coming over a place where the air is much heated. They do not cool the air; it is the wind that brings them which makes the weather cooler. If a thunder-storm comes up from the east, the weather will not be cooler after it. This will not happen till another storm comes up from the west. Thunder-storms are more violent the greater the difference of temperature between the two currents of wind which produce them.

Toothache.

Toothache is often a forerunner of some change of weather, like other pains, and particularly that species which depends on inflammation of a diseased socket or gum. In certain kinds of weather, and particularly before rain or showers, decayed teeth and diseased gums are very uneasy, and the pain often ceases when the rain begins to fall. The periods of that sort of toothache which depends on the exposure of the nerve in the cavity of the tooth seem to exist independently of any particular weather, and occur most frequently during the night, when the patient first gets warm in bed. The progress of this sort of toothache is often as follows: The pain after awhile becomes continuous instead of being periodical, and by degrees subsides, but the socket then and ultimately the gum become diseased, and are thence liable to be affected by the state of the weather above described. (Forster's Encyclopædia of Natural Phenomena.)

Tortoises.

Tortoises creep deep into the ground so as to completely conceal themselves from view when a severe winter is to follow. When a mild winter is to follow they go down just far enough to protect the opening of their shells.

Trees.

Trees snapping and cracking in the fall indicates cold weather.

Vernal Equinox.

If the wind is northeast at vernal equinox, it will be a good sea-

son for wheat and a poor one for corn; but if south or southwest, it will be good for corn and bad for wheat.

Walls.

When in cold weather the walls begin to show dampness, the weather changes.

Water Bubbles.

When water bubbles from the ground, expect rain on the following day.

Wells.

Water rising in wells and springs indicates approaching rain.

Wet and Dry.

Dust in the wheat and dab in the oats—that is, sow wheat in dry weather and sow oats at any time, even in wind.

Wheat and Corn.

If the spring is dry, sow wheat; if it is wet, plant corn.

Wind.

The whirling wind the dust obeys,
And in the rapid eddy plays.

Winter Storms.

In winter, after the prevalence of easterly winds, if the barometer begins to fall and the thermometer to rise, a gale which commences to blow from the southeast will veer to southwest, while the barometer falls constantly. As soon as the wind passes the southwest point the barometer begins to rise, a heavy shower of rain falls, and a strong west-northwest or northwest wind may follow, after which the sky clears and the weather becomes colder.

Winter Storm.

If in winter the barometer rises very high, and a thick fog sets in, it is a sure sign that the southwest and northeast winds are "fighting each other." Neither of them can make head against the other, and there is a calm, but there is a great danger of such a state of things being followed by a bad gale.

Winter.

Six weeks from the time snow is seen on Mount Mansfield, winter comes to stay.

Wood Fire.

Wood-fire coals frequently snuffing during the winter months foretell snow.

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269 WEST ELEVENTH STREET,
New York City, October 16, 1882.

Sergeant NEWLIN, *U. S. S. Office,*
Cleveland, Ohio:

DEAR SIR: I send with this two selections, taken as stated. Although, perhaps, not quite what you seek, there may be enough in them to warrant your perusing. As to their fitness for the purposes you demand I leave to you.

Trusting they may not be unacceptable, I am, very respectfully,
Your obedient servant,

CHAS. WARD RAYMOND.

The following poems are, perhaps, more curious than interesting. They afford, however, some idea of the superstitious dread with which the advent of Christmas day must have been regarded in these early times, not merely by the vulgar, but by all classes of our forefathers, for the Francis Moores and Raphaels of the fifteenth century found even kings willing believers in their extravagant predictions. From the allusions in each verse of the first poem to the risks that those who steal subject themselves to, one would almost suppose thieving to have been the fashionable vice of the age, practiced alike by both rich and poor, and that there was great need of such injunctions against it.

Both of these poems are from the same Harleian MS. in the British Museum (No. 2252, fols. 153–4). Christmas with the poets. London. David Bogue, 86 Fleet street. 1855.

I.

Lordlings, all of you I warn:
If the day that Christ was born
Fall upon a Sunday,
The winter shall be good I say,
But great winds aloft shall be;
The summer shall be fair and dry.
By kind skill and without loss,
Through all lands there shall be peace,
Good time for all things to be done,
But he that stealeth shall be found soon;
What child that day born may be,
A great lord he shall live to be.

If Christmas day on Monday be,
A great winter that year you'll see,
And full of winds, both loud and shrill,
But in the summer, truth to tell,
Stern winds shall there be and strong,
Full of tempests lasting long;
While battles they shall multiply,
And great plenty of beasts shall die.
They that be born that day I mean,
They shall be strong each one and keen.
He shall be found that stealeth ought,
Though thou be sick thou dieth not.

If Christmas day on Tuesday be,
That year shall many women die,
And that winter grow great marvels;
Ships shall be in great perils.
That year shall kings and lords be slain,
And many other people near them;
A dry summer that year shall be,
As all that are born therein may see;
They shall be strong and covetous.
If thou steal aught, thou losest thy life,
For thou shalt die through sword or knife
But if thou fall sick 'tis certain
Thou shalt turn to life again.

If Christmas day, the truth to say,
Fall upon a Wednesday,
There shall be a hard winter and strong,
With many hideous winds among.
The summer merry and good shall be,
And that year wheat in great plenty;
Young folks shall die that year, also,
And ships at sea shall have great woe.
Whatever child that day born is,
He shall be doughty and gay, I wis,
And wise and crafty also of deed,
And find many in clothes and bread.

If Christmas day on Thursday be
A windy winter you shall see;
Windy weather in each week,
And hard tempests strong and thick.
The summer shall be good and dry,
Corn and beasts shall multiply;
That year is good lands for to till;
Kings and princes shall die by skill.
If a child that day born should be,
It shall happen right well for thee;
Of deeds he shall be good and stable,
Wise of speech and reasonable.
Whoso that day goes thieving about,
He shall be punished without doubt;
And if sickness that day betide
It shall quickly from thee glide.

If Christmas day on Friday be,
The first of winter hard shall be;

With frost and snow, and with great flood,
But the end thereof it shall be good.
Again, the summer shall be good also;
Folk in their eyes shall have great woe;
Women with child, beasts, and corn,
Shall multiply and be lost none.
The child that is born on that day,
Shall live long and lecherous be alway.
Who stealeth ought shall be found out;
If thou be sick it lasteth not.

If Christmas day on Saturday fall,
That winter's to be dreaded by all;
It shall be so full of great tempest,
That it shall slay both man and beast;
Great store shall fail of fruit and corn,
And old folk die many a one.
What woman that day of child doth travail,
She shall give birth in great peril;
And children born that day by faith,
In half a year shall meet with death.
The summer shall be wet and ill;
Thou shalt suffer if aught thou steal;
Thou diest of sickness do thee take.

II.

If Christmas day on the Sunday be,
A troublous winter ye shall see,
Mingled with waters strong;
Good there shall be without fable,
For the summer shall be reasonable,
With storms at times among.

Wines that year shall all be good,
The harvest shall be wet with flood,
Pestilence shall fall on many a country;
Ere that sickness shall have past,
And while great tempests last,
Many young people dead shall be.

Princes that year with iron shall die,
There shall be changing of many lords high,
Amongst knights great debate,
Many tidings shall come to men,
Many wives shall be weeping then,
Both of poor and great estate.

The faith shall then be hurt truly,
For divers points of heresy
That shall then appear,
Through the tempting of the fiend;
And divers matters unkind,
Shall bring great danger near.

Cattle shall thrive one and the other,
Save oxen, they shall kill each other;
And some beasts they shall die;
Both fruit and corn will not be good,
Apples will be scarce for food,
And ships shall suffer on the sea.

That year on Monday, without fearing
All things well thou mayst begin,
They shall be profitable;
Children that on this day are born,
I' faith shall mighty be and strong,
Of wit full reasonable.

East Wind.

A change of wind, particularly a change from any other quarter to east, makes most people feel uncomfortable, and produces headaches in persons who are subject to them. Similar changes have the most violent effects when they happen about the new or full moon. It is difficult to ascertain in what degree the directions and changes of wind are under the influence of electricity, but there are many circumstances which would incline one to believe that these changes are dependent on some similar principle to that which causes atmospheric diseases in the human body, for certain winds, as well as certain changes of wind, are known to produce epidemics in many countries where violent atmospherical complaints pre-

vail; and in every country of the world I believe the east wind is almost proverbially unhealthy. Casual changes to east produce headache and nervous complaints, and a long-continued wind from that quarter produces an unwholesome season. Another curious thing is, that with east winds good astronomical observations cannot be made, the luminous objects seeming to dance or wave about in the field of the telescope. (Atmospheric Phenomena—Forster.)

Shooting-Stars a Prognostic of Bad Weather.

The connection between shooting-stars and bad weather, mentioned by many ancient writers, will appear probable if we consider certain facts established in the domain of modern science. Of all the various theories advanced to explain this startling phenomenon (termed meteor, fire-ball, shooting-star, moon-stone, sun-stone), that seems to be the most probable which considers them planetary bodies of very small size, circulating in an orbit round the sun, as our earth, and getting into that of the latter, entangled by her attraction, which occasionally brings down some of them upon her surface. Numerous planetary bodies, called Ceres, Pallas, &c., exist between Mars and Jupiter, and similar bodies of smaller dimensions may exist between the earth and its neighbors in the solar system.

Periodicy is a great fact in cosmical arrangements, and this phenomenon of shooting stars, &c., is strikingly periodical. Induced, apparently, by certain popular weather maxims among the French, M. C. St. Claire Deville has investigated the subject, and his conclusions are positive as to the "perturbations of the earth's temperature," coincident with the phenomenon as noticed from time immemorial in about the first fortnight of February, May, August, and November. M. Deville even ventures upon general conclusions from the fact. He says: "Do not all these considerations almost necessarily lead us to infer the influence of these critical periods, by their sudden variations of temperature, not only on the health of the vegetable creation, but that of the human race? Should we not examine the registers of hospitals, to see if certain diseases are not more frequent on certain days of certain years? Can we not even go back to the past and see, in the history and chronicles of past ages, if there are some traces of periodicy in certain great perturbations in the health of nations like the two invasions of cholera, which perhaps by chance occurred in 1832 and in 1849, about the center of the two critical periods, and which came from the north like the aurora borealis, since it seems, also, that it is these great atmospheric waves that propagate the perturbations of temperature?" In confirmation of this view we may notice the cattle plague, and the cholera still hovering over us and likely to recommence its ravages.

Professor Erman, of Berlin, writing to Arago, in 1840, said that "the two swarms or currents of asteroids (planetary bodies) which the earth meets on the ecliptic, respectively, about the 10th of August and the 13th of November, annually intervene between the earth and the sun, the first in the days between the 5th and 11th of February, the second from the 10th to 15th of May. Each of these conjunctions annually causes at those dates a very remarkable extinction of the heating ray of the sun, and thereby lowers the temperature at all points of the surface of the globe."

With respect to the November display of the phenomenon, it appears that its maximum was in 1799 and in 1833. Since then it has almost entirely ceased, but according to the prediction of Olbers it will resume the ascendant in 1867. Humboldt and others have reported on these displays, but that of the night of the 12th and 13th of November, 1833, in the United States, as described by Olmstead, needs only to be mentioned for our present purpose. No less than 300,000 masses, forming parts of the solar system, passed through that part of our terrestrial atmosphere which was visible at Boston, Mass.

"It was supposed that they were only stopped in the atmosphere and prevented from reaching the earth by transferring their motion to columns of air, large volumes of which they would suddenly and violently displace.

"It was remarked that the state of the weather and the condition of the seasons following this meteoric shower were just such as might have been anticipated from these disturbing circumstances of the atmospheric equilibrium."

M. C. Gravier believes that meteors show the direction of the coming wind; that their slow motion foretells a calm to ensue, or to continue if it exists; in fact, he says they are our weather-cocks and anemometers in the upper regions of the sky. He predicts that the rest of the present year (1866) will be more dry than wet, and the temperature above the average.

Our object in this article is merely to draw attention to the critical periods. It is obvious that if the passage of these meteors take place by day we cannot see them, so that their non-appearance is no reason why we should not be on our guard. From a list of storms obligingly given us by the meteorologic office as having in past years occurred at or about some of the periods we have named, and from our own investigations, we believe that the subject is worthy of attention, suggestive of caution at those critical periods, and altogether deserving a more lengthy consideration than we can give it in our limited space on this occasion.

During the great Barbadoes hurricane, August 10, 1831, fiery meteors fell perpendicularly from a vast height. The correspondence of the date, August 10th, is striking, and all are familiar with the great "November Atmospheric Wave," and its storms, especially the great Crimean hurricane of disastrous memory (November 14, 1855). (Manual of Weathercasts, by Andrew Steinmetz.)

The following interesting report relative to weather prognostics of the Zuñi Indians was furnished by Mr. G. H. Cushing, assistant ethnologist of the Smithsonian Institution:

ZUÑI, NEW MEXICO,
September 29, 1882.

D. D. GRAHAM, Esq.,
Acting subagent of the Zuñi Pueblo Indians:

DEAR SIR: I have the honor to submit herewith a few hastily-prepared statements from my notes relative to the weather prognostics, proverbs, &c., of the Zuñi Indians:

With these Indians the study of weather, both from practical and superstitious standpoints, has been the result of necessity, the growth of generations. It is therefore no matter of surprise that

the accompanying questions penetrate a rich domain with them of research.

Indeed, nothing short of a moderately lengthy treatise would do the subject, which is withal popularly a most interesting one, justice.

Zuñi worship, like that of the ancient Greeks, relates principally to this life.

To this life water is considered the greatest of necessities and blessings. Hence, rain, the clouds, springs, and all beings, things, and phenomena related to them, are regarded as sacred. A better understanding of this may be gleaned from the fact that in Zuñi mythology the sky and the celestial bodies, many terrestrial objects, and all phenomena of either, are regarded not less than all organized beings as animate and conscious existences, the whole, including man, being denominated *á hâ i*, or, The Beings. The greater number of the latter are included under two great classes:

1. Kia-pin = á-hâ-i; and
2. Kiä-shëm = á-hâ-i; the former signifying—
1. Beings (belonging) *to* water, and the latter,
2. Beings *of* the water.

These *beings*, as above explained, include all *phenomena* or *objects* connected with water, are supposed to control greatly the weather, &c.; hence the sayings relative to them and their influence are legion.

I have selected only a few of the principal of these, illustrative merely of the questions which I find in General Hazen's blank, regretting that lack of time does not permit of a more exhaustive treatment of his subject.

In order that a few examples of the original Zuñi may be given with the English renditions, I have answered the questions on a separate piece of paper, indicating them by their number, as given in General Hazen's blank.

1. The Sun.

"Yä to k'ia kiá kwap, i lo na kia ná, thli to nì ä hi ha." (When the sun is in his house (*i. e.*, in a halo or circle) cloud it will, rain will come soon.)

"Yä to k'ia kwa k'ets a nam hortil k wa tâp, i tchi tin gä mu k'ia ni ha, thli te kwa ni k'ia ná." (When the sun sets unhappily (with a haze-veiled face) then will the morning be angry with wind, storm, and sand.)

2. The Moon.

The moon, being a deity of the lives of men, does not belong to the "*k'iä she ma hâi;*" hence the proverbs relative to her, the legion, have little connection with weather prognostics. Two, however, are very often repeated: Yä o non kia kwop, í lo na kia ná, thli to kiaw i a ni ha; meaning, the moon, if in house be, cloud it will, rain soon will come. Yä o non an no pon i shi la a kiap (the moon, her face, if red be), kiä shë ma an te peie á (of water speaks she). The changes in the moon indicate rather changes in the affairs of men than in weather.

3. The Stars.

With the exception of six of the stars, viz: of the north, of the west, of the south, of the morning, of the evening, of the zenith, and of the lower regions (or horizon), the smaller celestial bodies re-

late also more to the affairs of men than to the weather. ' These six are spoken of as are the sun and moon. There is, however, one proverb which differs from those of the latter: Morgä tchu we in sha na í mup, a li hórtel té k'ia na. The stars sit still if they do (the times) to be pleasant are. (When the stars sit still the times are to be pleasant).

4. **The Rainbow.**

A mi to lan u ha í ton illi; thli to i peyu á. (The rainbow has but a bad character: she ever commands the rains to cease.)

5. **The Fogs.**

Shi wai a horthl yëil la ke'a á pei ni up, té tsï ti i há. (When the mist rolls down from the mountains, cold will it be.)

6. **The Dew.**

"When the dew is seen shining on the leaves, So ho! the mist rolled down from the mountains last night, &c." (See proverbs relating to fog.)

7. **The Clouds.**

"When the clouds rise in terraces of white, soon will the country of the corn-priests be pierced with the arrows of rain."

"When the clouds rise in balls of blue mist from the horizon, snow will soon whiten the country of the corn-priests."

8. **The Frost.**

With the coming of the frost grows the corn old.

9. **The Snow.**

"If much snow be spread on the mountains in winter, the season of planting will be made blue with verdure."

10. **The Rain.**

"With the north rain leaves the harvest."

The west rain, it comes from the world of waters to moisten the home of the Shi wi (Zuñi).

The south rain brings with it the beautiful odors of the hand of everlasting summer and brightens the leaves of growing things.

"With the rain of the northeast comes the ice fruit (hail)."

11. **The Thunder.**

The distant thunder speaks of coming rain."

With the first thunder the Beloved (gods of rain) open their portals.

It first thunders in the north: Aha! the bear has stretched his left leg in his winter bed.

It first thunders in the west: Aha! the bear has stretched his left arm in his winter bed.

It first thunders in the south: Aha! the bear has stretched his right leg in his winter bed.

It first thunders in the east: Aha! the bear has stretched his right arm, and comes forth, and then winter is over.

12. **The Winds.**

Wind from the north, cold and snow.

Wind from the western rim of the northland, snow.

Wind from the world of waters, clouds.

Wind from the southern rim of the world of waters, rain.

Wind from the land of the beautiful red, lovely odors, and rain.

Wind from the wooded cañons, rain and mist-clouds.

Wind from the land of day it is the breath of health, and brings the days of long life.

Winds from the lands of cold, the rain before which flees the harvest. Winds from the lands of cold, the fruit of ice.

Winds from the right hand of the west is the breath of the god of sand-clouds.

13. Zoothistic Prognostics.

I am compelled to leave this department, from want of detailed notes, almost untouched, although there is scarcely an action of the animals without its interpretation, either relative to weather or to the affairs of men.

13. Bats.

Bats who speak flying, tell of rain for to-morrow.

14. Birds.

When chimney-swallows circle and call, they speak of rain.

When the bluebirds twitter and sing, they call to one another of rain.

When the summer birds take their flight, goes the summer with them.

16. Frogs.

When the frogs warble, they herald the rain.

17. Butterfly.

When the butterfly comes, comes also the summer.

When the flowers dry up, the birds of summer flee. See also proverbs relative to summer birds (14).

When the world is damp, spring the seeds of the beloved (mushrooms and other apparently spontaneous growths).

19. "When the locks of the Navajos grow damp in the scalp-house, surely it will rain."

The seasons in Zuñi are only three—spring, summer, and winter. They are supposed to result from the change of weather and the will of the sun; hence are themselves prognosticated.

The months are lunar, and there are no days of the Christian week, save Sunday, when the Indians cannot trade, and which for this reason they know of.

Relative to proverbs of the months and seasons, I can only say there are many, but, as in the case with other matters above alluded to, they are rather relative to the affairs of life (mostly sacred obligations and observances) than to weather and agricultural operations.

Very respectfully,

G. H. CUSHING,
Assistant Ethnologist.

PART II.

INSTRUMENTAL AND OTHER LOCAL INDICATIONS OF APPROACHING STORMS.

[Compiled from reports made to the Chief Signal Officer by observers of the Signal Service, U. S. A.]

Albany, N. Y.

Storms set in with southerly winds, and are always preceded by falling barometer, and usually by falling temperature, with nimbus or cumulo-stratus clouds.

Alpena, Mich.

Cirrus, cirro-cumulus or cirro-stratus clouds in upper, and a dull haze in lower atmosphere. Lower winds from westerly direction, falling barometer and rising temperature.

Atlantic City, N. J.

Coronas and halos; prevalent haziness in lower atmosphere; cirro-stratus clouds; unusual amount of humidity; stationary barometer occurring after either a considerable rise or fall of the mercury; backing winds.

Augusta, Ga.

Slowly falling barometer, with rising temperature, and wind from the east or southeast, usually indicates rain, which continues until wind veers to the west or northwest; cirro-stratus clouds precede wind and rain, and are frequently noted from one to three days in advance.

Baltimore, Md.

General storms by very high barometer, dense haze, light, variable winds from east or northeast.

Southeast and southwest storms preceded by high temperature, low barometer, and brisk northwest winds.

Local storms preceded by unusually high temperature, cumulus clouds, and rapidly falling barometer.

Fort Benton, Montana Ter.

Wind storms, preceded by low barometer, low humidity, cirrus or cumulus clouds, with wind from west or southwest, generally the latter.

Rain, preceded by cumulo-stratus clouds, with wind from west to north and northeast, barometer moderately low, remaining stationary during storm.

Snow-storm, same condition as rain, except that barometer falls and stratus clouds prevail.

Bismarck, Dak.

Rapidly falling barometer, rising temperature, and light southerly winds indicate rain or snow, according to season of year.

Falling barometer, rising temperature, with wind from northeast or east, indicate snow.

Fine cirrus and cirro-stratus, floating low, presage wind.

Haze in night or early morning, or cumulus clouds, sharp and well defined, moving from west or southwest, indicate fair weather.

When snow is falling, and the wind backs from east to north, with decreasing velocity, clear weather may be expected.

Breckenridge, Minn.

Sudden movement of barometer in either direction, rising temperature, light cumulus clouds, with northwest wind, precede wind-storms.

Sudden depression of barometer, rising temperature, cumulus or cumulo-stratus clouds, with southeast wind, precede rain or snow storms.

An approaching storm is indicated by unusual clearness of the atmosphere, and frequently by lunar halos.

Buffalo, N. Y.

Rising barometer, with comparatively clear sky, mild temperature and light to fresh winds from west to southwest.

Light cirrus or cirro-stratus clouds move from the west, apparently very high in the atmosphere; humidity and wind decrease, and occasionally a calm ensues. This is followed by light winds from northeast, east, or southeast. Barometer begins to fall, and temperature to rise slowly; humidity increases steadily; cumulus clouds appear, moving slowly from west or southwest, and are soon followed by cumulo-stratus; wind increases in velocity, and shortly before precipitation occurs a dense white vapor, resembling haze, and moving with the surface current, gradually covers the whole sky.

Wind-storms are preceded by unusually rapid barometric depression, increase in temperature and humidity, stratus or cumulo-stratus clouds, with southwest winds. Water at the head of Lake Erie rises in advance of the storm.

Burlington, Vt.

Rapidly falling barometer, rising temperature, and cumulo-stratus or stratus clouds, with wind from south or southwest.

Cairo, Ill.

Falling barometer, rising temperature, stratus or cumulo-stratus, with wind from the south or southwest, precede rain; wind-storms are preceded by rising barometer, falling temperature, and cirro-stratus clouds, with brisk wind from west or northwest. Well defined lunar halos are followed by rain.

Cape Henry, Va.

Northeast storms are preceded by rapidly rising barometer and upper clouds (usually cirrus), moving rapidly from northeast in long white sheets changing to stratus in short time, and covering the whole sky.

Southeast storms are preceded by rapidly falling barometer, unusually low humidity and variable southwest winds. Heavy ocean-swell in advance of storm and from same direction in which storm is advancing.

Cape Hatteras, N. C.

Winter rain storms preceded by rapidly falling barometer and heavy cirro-stratus clouds, with wind from southeast or southwest.

Upper clouds moving from southwest indicate rain, but if from west or northwest, fair weather.

Heavy ocean-swell from southeast indicates rain from that direction. Wind storms preceded by dense haze, rapidly falling barometer, and rising temperature with southerly winds and with northerly winds, rising barometer, and falling temperature with low humidity.

Cape May, N. J.

Easterly storms are generally preceded from twelve to twenty-four hours by an unusually clear atmosphere, with high barometer and temperature. Light winds prevail and mirage in various forms, but more particularly the variety known as "loom," which enlarges distant objects in such a manner as to render distance very deceptive. The sea comes in with a long, heavy, easterly, ground swell, and a decided increase occurs in the rise of the tides. An unusual twinkling of stars is observed, and a larger number of them are visible, extending nearly to the horizon. The first clouds are generally cirrus, from the west or southwest, followed often by haze, which gradually thickens and lowers into a stratus, forming a heavy bank in the southwest, which gradually extends over and into the northeast, the whole mass deepening and lowering until nimbus clouds form and appear moving with the wind. Storms of the greatest severity and duration are generally with the wind from north-northeast to east-northeast, and rapidly increase in violence. They are attended with, or preceded by, a rapid depression of the barometer. Temperature rises for a veering, and falls for a backing, wind.

Easterly storms, slowly forming, are attended by moderate winds.

Storms from the southeast are often violent, but of short duration, lasting only from six to twelve hours, and shifting suddenly to the opposite direction.

Charleston, S. C.

During the months of April, May, June, July, August, and September, storms are preceded by slowly diminishing pressure, rising temperature, increasing humidity, and cumulus clouds, with wind from the west and northwest.

Winter storms come from the northeast and southeast. Those from the northeast are preceded, for several days, by brisk wind from that direction, rapidly rising barometer, slowly falling temperature, increasing humidity, with stratus clouds moving slowly from the northeast until the whole sky is covered and a dense mist begins to fall, which soon becomes rain as the clouds approach the earth. Storms from the southeast are the most dangerous. They are preceded by light and variable southeast winds, falling barometer, and rising temperature. The day immediately preceding the

storm is generally a fine one, with a few cirrus or cirro-stratus clouds, increasing humidity, wind variable, and rising slowly.

Cheyenne, W. T.

Rain-storms are preceded by a low barometer from twenty-four to forty-eight hours before their arrival, with wind from southeast, east, northeast, and north.

Snow-storms strike the station from southwest, northwest, or north, all storms of magnitude coming from the latter direction.

Wind-storms are preceded by a low barometer, with much briefer warning than in the case of rain and snow storms, often occurring within two or three hours after the first instrumental premonition. Temperature rises and humidity increases; cirrus clouds move from west to northwest.

Cincinnati, Ohio.

Ordinary rain storms, preceded by falling barometer, increased temperature, hazy atmosphere, cirrus clouds, and northeast wind.

Corsicana, Tex.

Approach of norther indicated by bank of clouds in north or northwest when the balance of sky is clear.

Gentle or brisk east wind precedes rain. Southwest or west wind indicates the approach of clear, dry weather.

Davenport, Iowa.

Rain storms generally preceded by an east, southeast, or south wind.

Wind storms preceded by steadily falling barometer, with light wind from southwest.

Denver, Colo.

Falling barometer, rising temperature, cirro-stratus clouds, with westerly winds. Most reliable indications of storms are seen to the north and west on the mountains. A cap of clouds on the high peaks, or low cumuli below the summits, presage rain or snow. For wind, a black wall of cloud generally forms between high peaks and the foot-hills, completely hiding the peaks and extending only five or ten degrees above the horizon.

Detroit, Mich.

Falling barometer from twelve to twenty-four hours in advance of storm, with wind from southeast or northeast.

Dodge City, Kans.

Falling barometer, with light southeast wind, hazy atmosphere, cirrus clouds, and low humidity.

Dubuque, Iowa.

Wind storms preceded by rapid fall of barometer, with cirro-stratus and stratus clouds moving from the west; wind changeable, backing from southeast to west.

Rain-storms preceded by slowly falling barometer and large masses of cirrus and cirro-cumulus moving from southeast. Surface winds southwest, south, and southeast.

Duluth, Minn.

Northeast storms, preceded by hazy atmosphere and fog over the lake, the former turning to stratus and the latter to nimbus cloud

as storm approaches. Falling barometer, increasing humidity, and falling temperature.

Northwest storms by low and falling barometer, rising temperature, high and increasing humidity, with cumulus and cumulo stratus clouds. This class of storms most frequent in winter and spring.

Northern storms by falling barometer, falling temperature, increasing humidity, and cumulus clouds; most frequent in winter, and accompanied by snow.

Southern storms by falling barometer, rising temperature, increasing humidity, with hazy atmosphere.

Eastern storms by high and rising barometer, rising temperature, increasing humidity, with stratus clouds.

Western storms by falling barometer, high or rising temperature, and humidity, with heavy banks of stratus clouds in western sky. Occur at all seasons of year.

Fogs are usually followed by rain within twenty-four hours.

Eastport, Me.

Northeast storms are preceded by slowly falling barometer, falling temperature, stratus clouds in the east, which spread over the entire sky.

Southeast storms are preceded by heavy fall of barometer, falling temperature, increasing humidity, stratus clouds, and detached "scud," with wind shifting from east to southeast.

In summer a continuance of southeast wind is followed by rain. Sea-gulls gather together in flocks near the shore, uttering a peculiar cry.

Erie, Pa.

Storms from north, northwest, and west are preceded by falling barometer, brisk to high southerly winds, rising temperature, and increasing humidity.

Storms from the southwest to southeast are preceded by slowly falling barometer, rising temperature. With steady south wind at any season of the year rain is probable within twelve hours.

Fort Gibson, Indian Ter.

Falling barometer, rising temperature and low humidity, the latter forming an important element. If wind veers suddenly from southwest to west, rain follows; if this change occurs slowly, wind follows.

Cirro stratus changing to cumulo stratus twenty-four to forty-eight hours in advance of storm.

Fort Sully, Dak.

Rapidly rising and very high barometer, low temperature, cirrus or cirro-stratus clouds moving from the north or northwest, with surface wind from southeast, backing to north and northwest. High summer temperature, usually followed by brisk and high south and southeast wind.

Galveston, Tex.

"Northers," preceded by slowly falling barometer, decreasing humidity, wind south or southeast, veering to north, with cirrus or cirro-cumulus clouds moving from west or northwest.

Indianapolis, Ind.

Sudden storms, by sudden fall of barometer, increase of temperature, high humidity, with haze in lower and cirrus clouds in upper atmosphere, moving from the west.

Winter storms, by high and rising barometer, rising temperature, low humidity, cirrus and cirro-stratus clouds moving from the west. These followed by falling barometer, with wind veering to east and southeast, and stratus clouds.

Indianola, Tex.

"Northers" are preceded by protracted southeast winds, rapid rise of barometer from four to six hours in advance of storm, high humidity, with cirrus clouds moving from the west.

Jacksonville, Fla.

Falling barometer and rising temperature from four to six days in advance of storm. Hazy atmosphere, wind north to northeast, cirrus clouds moving from west and southwest; wind veering to east, southeast, and southwest.

Keokuk, Iowa.

Falling barometer and cirrus clouds, with fresh easterly wind, precede rain or snow, according to season.

Key West, Fla.

"Northers," from October to May, preceded by hazy atmosphere, easterly winds veering to southerly, cirrus, cirro-stratus, and cirro-cumulus clouds, moving slowly from the southwest and west, and finally a bank of stratus clouds in the western horizon, apparently stationary. Falling barometer, high and rising temperature and humidity.

Cyclones from July to November are preceded by northerly and easterly fresh and brisk winds, drizzling rains at intervals, for several days, low and nearly stationary barometer, steady, high temperature, dark scud flying low, with surface wind, and cirrus, cirro-stratus, and cirro-cumulus clouds above, moving slowly from the south and west. The height and action of barometer and state of weather are the most notable signs.

Rain storms prevail from May to November, are preceded by hazy, close atmosphere, average low barometer, high temperature, rising of "thunder heads" in the horizon in the direction from which rain is to be expected, with an almost imperceptible motion and an appreciable fall of barometer, several hours before storm approaches.

Knoxville, Tenn.

Barometer moves rapidly for a storm of short duration, temperature rises, wind from east-southeast, south and southwest, from eight to twenty-four hours previously, with upper clouds moving from the west, wind stronger and of greater duration, with rising rather than falling barometer. Rapid movement of cirro-stratus clouds indicates wind, but is seldom observed.

La Crosse, Wis.

Barometer falls steadily for twenty-four hours, with rising temperature, increased humidity, and cirro-stratus clouds before rain. Wind storms same as above, with addition of cirrus of great elevation moving in opposite direction to surface wind, and apparently

highly electrified. Winter storms are preceded by gentle south or southwest wind, veering to north or northeast.

Leavenworth, Kans.

Rain storms are preceded from twelve to forty-eight hours by barometer falling steadily, increasing humidity, high temperature, with wind east or south, cirro-stratus clouds in southern or western horizon, and eastern horizon obscured by haze.

Red sky at sunrise indicates strong winds; if humidity is much below the mean, the color is usually a brilliant scarlet; if humidity is high, the color is more crimson, with a purple tinge and rain follows. When wind backs from northwest to southwest, clear weather follows.

Lexington, Ky.

Local storms are preceded by falling barometer, unusually high temperature, low humidity, and cumulus clouds; northwest storms, by falling barometer, cirrus clouds and wind veering to east; southwest storms, by falling barometer, unusually high temperature with wind backing to east and northeast.

Louisville, Ky.

Barometer falling slowly for forty-eight hours, unusually high temperature and humidity, cirro-stratus clouds in morning for two or three days in advance of storm, and light south wind.

Winter storms are generally from the northwest, with falling barometer for twenty-four hours in advance.

Long Branch, N. J.

For northeast storm, falling barometer, rising temperature, cirro-cumulus or cirro-stratus clouds, moving from west or southwest with lower atmosphere hazy. If wind backs to northeast from southwest, precipitation is greater than when it veers to the same quarter. For eastern storms same conditions, except, that upper clouds move from the westward. For northwestern storms the fall of barometer is most rapid.

Lynchburg, Va.

Long-continued rain storms are preceded from six to twelve hours by rising barometer, cirrus clouds moving from the southwest, with surface wind for the northeast.

Hazy and smoky atmosphere indicates rain. Before rain, especially when wind is in the south, the leaves of the maple, aspen, poplar, and willow trees curl up so as to show their under side. When cumulus clouds drift over low enough to cast perceptible shadows, rain generally follows within forty-eight hours.

Marquette, Mich.

Falling barometer for twenty-four or forty-eight hours, rising temperature, southerly wind, with cirro-stratus clouds moving from a westerly or southwesterly direction.

Memphis, Tenn.

Northwest storms are preceded by slow fall of barometer at first, followed by a more rapid fall as storm approaches; fresh southwest winds, backing to southeast, rising temperature and humidity, with slow formation of stratus clouds.

Greatest rainfall occurs with southeasterly winds.

Southwest and west storms are preceded by winds from the north-

east and east, with same instrumental indications as for northwest storms.

Mobile, Ala.

Barometer falls slowly ten or twelve hours, and more rapidly two or three hours before storm; stratus clouds with southeast wind.

Morgantown, W. Va.

Falling barometer, rising temperature and humidity, with southwest or west winds, and cirrus clouds moving from the westward.

In winter a storm usually follows a falling barometer, with south wind. If barometer falls one-tenth of an inch between 7 a. m. and 12 m., bad weather follows within thirty hours. In winter, high temperatures are generally followed by bad weather, especially if accompanied by winds varying from northwest to northeast.

Increase of humidity between 12 m. and 3 p. m. is usually followed by rain before night on same day.

Backing of wind to southward, with falling barometer, nearly always followed by bad weather.

All wavy forms of cirro-stratus are sure signs of an approaching storm. In summer, when cirrus moves from northwest or north, a storm follows within thirty-eight hours.

Mount Washington, N. H.

Falling barometer, falling temperature, and cirro-stratus clouds moving from a northerly direction. When in small quantities these clouds indicate wind, and when in large quanties rain.

Nashville, Tenn.

Barometer falling slowly from twelve to forty-eight hours, increasing temperature and humidity, cirro-stratus clouds moving from southwest, with easterly surface wind from one to three days in advance of storm.

Crimson sky in morning is generally followed by rain within twelve hours.

New Haven, Conn. (Furnished by Prof. E. Loomis.)

Great storms are frequently preceded by an unusually pleasant day, so that a very transparent atmosphere may, perhaps, be regarded as an indication that a storm may be looked for within twenty-four hours.

One of the first indications that we are on the edge of a great storm consists in a slight turbidness of the atmosphere which would scarcely attract the attention of an ordinary observer, but which is sufficient to cause solar halos during the day and lunar halos during the night, if there is a moon. During the colder months of the year, our great storms are usually preceded by a rise of the barometer above the mean and a veering of the wind to the northeast. If the barometer rises considerably above the mean, and is accompanied by a fresh wind from the northeast, a storm is pretty sure to follow within twelve hours.

A considerable fall of snow is very frequently preceded for several hours by the same signs (high barometer and northeast wind), together with a feeling of extreme chilliness, much greater than is usually experienced with the existing state of the thermometer.

During the warmer months a strong breeze from the south, accompanied by towering cumulus clouds, is pretty sure to be followed by rain within a few hours, generally a thunder storm. The

phenomenon which is most decidedly local in New Haven is the direction of the prevalent wind, together with the diurnal change in the wind's direction. During the six colder months of the year the prevalent wind is from the north-northwest, and the diurnal change in the wind's direction is slight. During the six summer months the wind in the morning usually blows from the north or northwest, but by noon, and sometimes by 10 a. m., it veers to the south or southwest, and continues thus for the remainder of the day. This peculiarity is supposed to be due to the difference of temperature between the land and the neighboring water, and it modifies, very sensibly, the direction of the New Haven wind in the neighborhood of the storm centre. During the passage of a great storm the wind at New Haven is much more northerly than is experienced at interior stations similarly situated with reference to a storm centre.

New London, Conn.

Falling barometer, rising temperature, cirrus and cirro-stratus clouds moving from the westward, light scud over the sea horizon moving with the surface wind, which is usually from the southwest. Humidity increases, and tides are of unusual height.

New Orleans, La.

Rapid movement of upper clouds, with little or no wind at surface. Falling barometer for several days in advance of storm, with rising temperature. Southerly winds precede rain, with cirro-stratus clouds moving from the westward.

New York, N. Y.

Rain storms, preceded by falling barometer, rising temperature, increasing humidity, cirrus clouds in upper with stratus in lower atmosphere, spreading gradually over the whole sky from the eastward.

Wind storms from an easterly direction, preceded by rapidly falling barometer, with frequent oscillations, rising temperature, increasing humidity moving rapidly at a great height.

Westerly storms, by rapidly rising barometer, free from oscillations, falling temperature, increasing humidity, changeable winds, with cirrus clouds in upper and stratus in lower atmosphere.

Norfolk, Va.

High and rapidly falling barometer, rising temperature, low humidity, unusually clear atmosphere, with southeast and east winds.

North Platte, Nebr.

Low followed by rising barometer, cumulus and cumulo-stratus clouds moving rapidly from northwest and west.

All storms approach from the northwest without reference to direction in which wind may blow previously.

Rain storms are preceded by north or northeast wind.

Omaha, Nebr.

Falling barometer, rising temperature, high and increasing humidity, and easterly winds.

Oswego, N. Y.

Wind storms are preceded by rapid fall of barometer, with wind veering from southeast to southwest, west, and northwest.

Rain storms, by oscillating barometer, with downward tendency, hazy atmosphere, gradually changing to cirro-stratus or cirro-cumulus clouds moving from the westward.

Northeast storms, by high barometer and low temperature.

Local storms, by sudden fall of barometer, rising temperature, low humidity, cumulo-stratus clouds in west or southwest.

Pembina, Dak.

Falling barometer, rising temperature, with wind from south, southeast, or southwest.

Philadelphia, Pa.

Falling barometer, rising temperature, easterly wind, haziness in upper atmosphere, followed by cirro-stratus clouds moving from the northwest.

Peck's Beach, N. J.

Rising barometer for two or three days, followed by sudden fall with heavy ocean-swell from the eastward, six or eight hours in advance of storm.

Pittsburgh, Pa.

Falling barometer fifteen to thirty hours in advance, rising temperature, variable easterly to southerly wind, with cirro-stratus clouds moving from southwest or west. A dense fog or haze indicates rain within twenty-four hours.

Port Huron, Mich.

Thick heavy haze or clouds in northwest, with southeast wind, indicates rain. Low and falling barometer, with wind from the west-northwest or east-northeast, indicates wind.

Portland, Me.

Rain storms are preceded by falling barometer, falling temperature, and southwest wind.

Wind storms by falling barometer, northwest wind veering to southeast, cirro-stratus and cumulo-stratus clouds moving from the southeast. Southeast storms are often preceded by hazy atmosphere in southeast.

Punta Rassa, Fla.

Falling barometer, west or southwest wind, cirrus clouds changing to cirro-stratus with high humidity.

If the change to cirro-stratus occurs rapidly, rain will probably follow within twenty-four hours.

Halos seen on successive nights indicate rain within twenty-four hours. Birds fly about wildly a few hours before a storm occurs, and men-of-war hawks, usually high fliers in clear weather, fly low in contracted circles. Cyclones and tornadoes, are preceded by hazy, slaty, and ominous appearance of sky, atmosphere sultry, wind variable, and generally from east or southeast, clouds bank up in the east, stratus clouds float unusually low and move swiftly, detached inky-looking scuds still lower and swifter.

Rochester, N. Y.

Falling barometer, rising temperature, east or southeast wind, low humidity, and clouds moving from the southwest. A northeast wind backing to northwest or west, or veering to southwest in winter, indicates rain or snow.

Sandy Hook, N. J.

Low and falling barometer, high and rising temperature, hazy atmosphere, with cumulo-stratus clouds moving from the west and southwest, and roaring sea.

San Diego, Cal.

Wind storms are of rare occurrence, and are preceded by warm east wind, with upper clouds moving from the west; oscillating barometer, with downward tendency, several days in advance of disturbance.

San Francisco, Cal.

Rain storms are preceded by falling barometer, low but rising temperature, and west wind. During the rainy season if wind veers to southeast rain follows.

Santa Fé, N. Mex.

Slight fall of barometer and rise of temperature, with cirrus clouds in their various formations, moving from the southwest.

Savannah, Ga.

Barometer above mean and rising slowly for twenty-four hours, remaining nearly stationary for six or eight hours, and then falling slowly, temperature opposite to movement of barometer, cirrus clouds forming near zenith, and moving to northeast.

Shreveport, La.

High and falling barometer, low humidity, and cirrus clouds calm or moving from the west.

Saint Louis, Mo.

Winter storms are preceded by falling barometer, southeast wind, cirro-stratus clouds and haze if temperature is high, and by stratus clouds if it is low. Summer storms, by stationary barometer, temperature above the mean, with cumulus and cirro-stratus clouds, the former in large masses.

Saint Mark's, Fla.

Barometer rises twenty-four hours before storm, with hazy atmosphere and south wind, the barometer beginning about six hours before storm to fall rapidly with rising temperature, and formation of cumulo-stratus clouds.

The tide rises rapidly.

Saint Paul, Minn.

Falling barometer, rising temperature, low humidity, southeast wind, with cirrus and cirro-stratus clouds.

Squan Beach, N. J.

Falling barometer, rising temperature, and dense haze; cirro-stratus clouds indicate wind and rain.

Toledo, Ohio.

Barometer falling rapidly, rising temperature, low humidity, easterly winds, cirrus clouds in western horizon moving eastward, followed by stratus until sky is obscured.

Tybee Island, Ga.

Northeast storms are preceded by rising barometer, falling temperature, low humidity, light cirrus clouds in bands from northwest

to southeast, and moving from north or west, with light to fresh surface wind from the south, and heavy sea swell from the northeast.

Southern storms by falling barometer, rising temperature, high humidity, heavy masses of cumulo-stratus clouds, moving from the southwest, smoky sky, heavy rolling surf, and gentle, variable, and shifting north to east winds.

When the wind backs from northeast to west a gale generally follows.

Vicksburg, Miss.

Slowly falling barometer, high and rising temperature, sky of dull, whitish appearance, resembling haze near horizon; cirrus clouds followed by dense masses of cumulus; wind in light puffs from an easterly direction.

Virginia City, Mont.

Winter storms are preceded by low barometer, falling temperature winds shifting suddenly from some westerly quarter to an easterly one.

Summer storms by falling barometer and temperature, with westerly winds and dense stratus clouds.

Wilmington, N. C.

Southeast storms are preceded by rapidly falling barometer, rising temperature, increasing cloudiness and humidity, wind backing to an easterly direction from the southwest or west, and cirro-stratus clouds moving from the west or northwest.

Northeast storms by high and rising barometer, falling temperature, increasing haziness, cirro-stratus clouds moving from the southwest, with light winds veering to the northward and variable.

Southwest storms by falling barometer, high temperature, and fair weather. Thunder storms by low or falling barometer, unusually high temperature, cumulus clouds in western horizon, wind shifting suddenly from south or southwest to the northward.

GENERAL PHENOMENA.

1. Sky becoming overcast with cirro-stratus clouds moving from the southwest, west, or northwest.
2. Increasing haziness, especially in the upper atmosphere after a spell of fair weather.
3. Halos and corona.
4. Variable light wind veering and backing frequently, with a tendency to an easterly direction.
5. Sun setting red among threatening clouds or giving the horizon a greenish tinge.
6. Heavy dews in summer.
7. Driving scud, with increasing humidity.

Wood's Holl, Mass.

Easterly storms are preceded by rapidly rising barometer and temperature, cirrus clouds in early morning moving slowly from the northwest twelve or fourteen hours before approach of storm, and unusually high tides.

Southerly storms by rapidly falling barometer, rising temperature, clouds moving rapidly from the southwest, heavy ocean swell, and tides running stronger, but not as high as before easterly storms.

Westerly storms by falling barometer, clouds moving in all directions, ocean greatly agitated, with low tides.

Sea birds come into harbor six or eight hours before storm arrives, and remain until it is over.

Wytheville, Va.

Slowly-falling barometer, rising temperature, east to southeast winds veering to west.

In winter snow storms are preceded by northeast winds, rising temperature, and slow fall of barometer.

Well-defined cirro-cumulus moving from any direction indicate rain.

Yankton, Dak.

Wind storms are preceded by falling barometer, sudden rise of temperature, clouds moving rapidly from the northwest, with southeast surface wind.

If a calm, with high temperature, occurs after a brisk northerly wind for twenty-four or forty-eight hours, a northwest gale may be expected.

Rain storms are preceded by barometric fluctuations, a hazy, ragged-edged, dark cloud, and wind from east to northeast.

The following tables contain the information heretofore published in pamphlet form under the title of "Rain and Dry Winds," computed for geographical districts.

Table I. Shows the quadrant from which the winds are most likely to be followed by rain or snow.

Table II. Shows the quadrant from which the winds are least likely to be followed by rain or snow.

These tables are computed from all the observations made by this bureau since its establishment to January 1, 1882.

The districts herein referred to are those adopted by this office as shown by the "District Map." For convenience of reference they are herein described at the foot of each table.

TABLE No. I.—*Winds most likely to be followed by rain or snow.*

1871 to 1881, INCLUSIVE.

Geographical district.	January.	February.	March.	April.	May.	June.
Eastern Gulf States	S to E	S to E	SW to SE	SW to SE	SW to SE	SW to SE
Key West and Punta Rassa	SE to NE	S to E	S to E	S to E	SE to NE	SE to NE
Lower Lake Region	SW to SE	SW to SE	SW to SE	SW to SE	W to S	W to S
Lower Mississippi Valley	SW to SE	S to E	S to E	S to E	SW to SE	SW to SE
Middle Atlantic States	SE to NE	S to E	S to E	S to E	SW to SE	SW to SE
Middle Eastern Rocky Mountain Slope.	NE to NW	E to N	E to N	E to N	SE to NE	S to E
Middle Pacific Coast Region	SW to SE	SW to SE	SW to SE	SW to SE	SW to SE	SW to SE
Middle Plateau District	SW to SE	SW to SE	SW to SE	SW to SE	NW to SW	NE to NW
Missouri Valley	NE to NW	NE to NW	S to E	SE to NE	S to E	S to E
New England States	SW to SE	SW to SE	S to E	S to E	SW to SE	SW to SE
Northern Rocky Mountain Slope.	NE to NW	NE to NW	NE to NW	NE to NW	NE to NW	SE to NE
North Pacific Coast Region	SW to SE	W to S	SW to SE	SW to SE	W to S	W to S
Northern Plateau District	W to S	SW to SE	SW to SE	NW to SW	W to S	NW to SW
Ohio Valley	SW to SE	SW to SE	SW to SE	SW to SE	SW to SE	SW to SE
Rio Grande Valley	SE to NE	SE to NE	SE to NE	SE to NE	SE to NE	S to E
South Atlantic States	E to N	SE to NE	W to S	SW to SE	SE to NE	SW to SE
Southeastern Rocky Mountain Slope.	E to N	S to E	S to E	S to E	S to E	S to E
South Pacific Coast Region	S to E	W to S	W to S	W to S	W to S	SW to SE
Southern Plateau District	W to S	W to S	SW to SE	W to S	SW to SE	S to E
Tennessee	SW to SE	SW to SE	SW to SE	SW to SE	SW to SE	W to S
Upper Lake Region	SW to SE	SW to SE	SE to NE	SE to NE	S to E	SW to SE
Upper Mississippi Valley	S to E	S to E	S to E	S to E	S to E	SW to SE
Western Gulf States	S to E	S to E	S to E	S to E	S to E	S to E

TABLE NO. I.—*Winds most likely to be followed by rain or snow*—Continued.

Geographical district.	July.	August.	September.	October.	November.	December.
Eastern Gulf States	SW to SE	S to E	S to E	S to E	S to E	S to E
Key West and Punta Rassa	SE to NE	SE to NE	SE to NE	SE to NE	SE to NE	SE to NE
Lower Lake Region	W to S	W to S	W to S	SW to SE	SW to SE	SW to SE
Lower Mississippi Valley	NW to SW	SW to SE	SW to SE	SW to SE	S to E	SE to NE
Middle Atlantic States	SW to SE	SW to SE	S to E	SW to SE	SW to SE	SW to SE
Middle Eastern Rocky Mountain Slope.	S to E	S to E	S to E	SE to NE	NE to NW	E to N
Middle Pacific Coast Region.	SW to SE	W to S	SW to SE	SW to SE	SW to SE	SW to SE
Middle Plateau District	N to W	SW to SE	SW to SE	SW to SE	W to S	SW to SE
Missouri Valley	S to E	S to E	S to E	S to E	NE to NW	NE to NW
New England States	SW to SE	SW to SE	SW to SE	SW to SE	SW to SE	NE to NW
Northern Rocky Mountain Slope.	S to E	SE to NE	NE to NW	NE to NW	N to W	NE to NW
North Pacific Coast Region.	W to S	SW to SE	SW to SE	W to S	SW to SE	S to E
Northern Plateau District	W to S	NW to SW	NW to SW	W to S	SW to SE	SW to SE
Ohio Valley	W to S	W to S	SW to SE	SW to SE	SW to SE	SW to SE
Rio Grande Valley	S to E	SE to NE	SE to NE	SE to NE	E to N	SE to NE
South Atlantic States	SW to SE	SW to SE	SE to NE	SE to NE	E to N	SW to SE
Southeastern Rocky Mountain Slope.	S to E	S to E	S to E	S to E	E to N	E to N
South Pacific Coast Region.	W to S	NW to SW	N to W	W to S	W to S	S to E
Southern Plateau District	SW to SE	S to E	SW to SE	SW to SE	S to E	W to S
Tennessee	W to S	W to S	SW to SE	SW to SE	SW to SE	W to S
Upper Lake Region	SW to SE	SW to SE	SW to SE	SW to SE	W to S	W to S
Upper Mississippi Valley	SW to SE	SW to SE	SW to SE	SW to SE	S to E	S to E
Western Gulf States	S to E	S to E	S to E	S to E	S to E	S to E

NOTES.

Eastern Gulf States.—Eastern Mississippi, Alabama, and Northwestern Florida.

Lower Lake Region.—Lake Erie and Ontario, with adjacent territory.

Lower Mississippi Valley.—A belt of country, 200 miles broad, from Cairo to Vicksburg. Below Vicksburg the character of the country so changes that it is no longer described as a valley.

Middle Atlantic States.—New York, New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, and Virginia as the Middle States, and that part of those States lying east of the Alleghanies as the Middle Atlantic States.

Middle Eastern Rocky Mountain Slope.—Eastern Colorado, Southern Nebraska, Kansas, northwestern portion of Indian Territory, portion of Northern Texas, also a portion of Northeastern New Mexico.

Middle Pacific Coast Region.—Those portions of California west of the Sierra Nevadas and north of the 37th parallel of latitude.

Middle Plateau District.—Western Colorado, Utah, Nevada, southwestern corner of Wyoming, and the portions of California lying east of the Sierra Nevadas.

Missouri Valley.—A belt of country 200 miles broad, from Fort Sully, Dak., to Jefferson City, Mo.

New England States.—Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island.

Northern Rocky Mountain Slope.—Those portions of Montana and Wyoming lying east of the Rocky Mountains, Southwestern Dakota, and Northwestern Nebraska.

North Pacific Region.—Those portions of Oregon and Washington Territory lying west of the Cascade range.

Northern Plateau District.—Portion of Western Wyoming, Western Montana, Idaho, and the portions of Oregon and Washington Territory lying east of the Cascade range.

Ohio Valley.—The belt of country, about 200 miles broad, from Pittsburgh, Pa., to Cairo, Ill.

Rio Grande Valley.—Southwestern Texas below the junction of the Rio Pecos with the Rio Grande.

South Atlantic States.—North Carolina, South Carolina, Georgia, and Northern and Eastern Florida.

Southeastern Rocky Mountain Slope.—Southeastern New Mexico, Central and Western Texas.

South Pacific Coast Region.—Those portions of California west of the Sierra Nevadas and south of the 37th parallel of latitude.

Southern Plateau District.—Western New Mexico, Arizona, and Southeastern California.

Upper Lake Region.—Lakes Superior, Huron, and Michigan, with adjacent country.

Upper Mississippi Valley.—The belt of country, about 200 miles broad, from Saint Paul to Cairo.

Western Gulf States.—Western Louisiana, Western Arkansas, Eastern Texas, Southern Missouri, and southeastern portion of Indian Territory.

TABLE No. II.—*Winds least likely to be followed by rain or snow.*

1871 to 1881, INCLUSIVE.

Geographical district.	January.	February.	March.	April.	May.	June.
Eastern Gulf States	NW to SW	NW to SW	N to W	N to W	N to W	NE to NW
Key West and Punta Rassa	NW to SW	N to W	N to W	N to W	N to W	N to W
Lower Lake Region	NE to NW	NE to NW	NE to NW	N to W	E to N	E to N
Lower Mississippi Valley	N to W	N to W	N to W	N to W	NE to NW	E to N
Middle Atlantic States	N to W	N to W	N to W	N to W	N to W	NE to NW
Middle Eastern Rocky Mountain Slope.	NW to SW	NW to SW	NW to SW	NW to SW	NW to SW	NW to SW
Middle Pacific Coast Region	E to N	E to N	NE to NW	E to N	E to N	NE to NW
Middle Plateau District	E to N	N to W	E to N	E to N	E to N	W to S
Missouri Valley	W to S	W to S	W to S	NW to SW	NW to SW	NW to SW
New England States	SE to NE	N to W	N to W	N to W	N to W	N to W
Northern Rocky Mountain Slope.	S to E	W to S	W to S	W to S	W to S	NW to SW
North Pacific Coast Region	NE to NW	NE to NW	E to N	E to N	SE to NE	SE to NE
Northern Plateau District	NE to NW	NE to NW	E to N	NE to NW	E to N	E to N
Ohio Valley	N to W	NE to NW	N to W	NE to NW	NE to NW	E to N
Rio Grande Valley	NW to SW	NW to SW	NW to SW	NW to SW	NW to SW	NW to SW
South Atlantic States	NW to SW	N to W	N to W	N to W	N to W	NE to NW
Southeastern Rocky Mountain Slope.	NW to SW	NW to SW	NW to SW	NW to SW	N to W	N to W
South Pacific Coast Region	NE to NW	NE to NW	NE to NW	E to N	E to N	E to N
Southern Plateau District	NE to NW	E to N	E to N	E to N	NE to NW	N to W
Tennessee	N to W	N to W	N to W	N to W	N to W	NE to NW
Upper Lake Region	E to N	N to W	N to W	N to W	N to W	N to W
Upper Mississippi Valley	NW to SW	NW to SW	NW to SW	N to W	N to W	NE to NW
Western Gulf States	NW to SW	N to W	NW to SW	N to W	N to W	N to W

Geographical district.	July.	August.	September.	October.	November.	December.
Eastern Gulf States	NE to NW	NE to NW	NW to SW	NW to SW	NW to SW	NW to SW
Key West and Punta Rassa	NE to NW	N to W	N to W	NW to SW	N to W	N to W
Lower Lake Region	E to N	E to N	NE to NW	NE to NW	NE to NW	NE to NW
Lower Mississippi Valley	E to N	E to N	NW to SW	N to W	NW to SW	N to W
Middle Atlantic States	E to N	N to W	N to W	N to W	N to W	N to W
Middle Eastern Rocky Mountain Slope.	NW to SW	W to S	NW to SW	NW to SW	NW to SW	W to S
Middle Pacific Coast Region	NE to NW	E to N	E to N	NE to NW	SE to NE	E to N
Middle Plateau District	SE to NE	E to N	E to N	E to N	E to N	E to N
Missouri Valley	NW to SW	N to W	NW to SW	NW to SW	W to S	W to S
New England States	N to W	N to W	N to W	N to W	N to W	NW to SW
Northern Rocky Mountain Slope.	NW to SW	NW to SW	SW to SE	SW to SE	SE to NE	W to S
North Pacific Coast Region	SE to NE	SE to NE	E to N	E to N	E to N	NE to NW
Northern Plateau District	SE to NE	S to E	S to E	E to N	E to N	NE to NW
Ohio Valley	E to N	E to N	N to W	E to N	N to W	N to W
Rio Grande Valley	NW to SW	NW to SW	NW to SW	NW to SW	W to S	W to S
South Atlantic States	N to W	N to W	N to W	NW to SW	NW to SW	N to W
Southeastern Rocky Mountain Slope.	N to W	N to W	NW to SW	NW to SW	NW to SW	NW to SW
South Pacific Coast Region	E to N	S to E	S to E	SE to NE	NE to NW	NE to NW
Southern Plateau District	NE to NW	NE to NW	NE to NW	NE to NW	NE to NW	E to N
Tennessee	NE to NW	E to N	N to W	N to W	N to W	N to W
Upper Lake Region	N to W	N to W	N to W	E to N	E to N	E to N
Upper Mississippi Valley	N to W	NE to NW	E to N	N to W	NW to SW	NW to SW
Western Gulf States	NE to NW	N to W	NW to SW	NW to SW	NW to SW	NW to SW

NOTES.

Eastern Gulf States.—Eastern Mississippi, Alabama, and Northwestern Florida.

Lower Lake Region.—Lakes Erie and Ontario with adjacent territory.

Lower Mississippi Valley.—A belt of country 200 miles broad, from Cairo to Vicksburg. Below Vicksburg the character of the country so changes that it is no longer described as a valley.

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Southern Plateau District.—Western New Mexico, Arizona, and Southeastern California.
Upper Lake Region.—Lakes Superior, Huron, and Michigan with adjacent country.
Upper Mississippi Valley.—The belt of country, about 200 miles broad, from Saint Paul to Cairo.
Western Gulf States.—Western Louisiana, Western Arkansas, Eastern Texas, Southern Missouri, and southeastern portion of Indian Territory,

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Watson, Sergt. J. M., Atlantic City, Atlantic County, New Jersey.
Watkins, R. B., Cincinnati, Hamilton County, Ohio.
Walkee, G. R., Winnemucca, Humboldt County, Nevada.
Welford, Jeannie, Memphis, Tenn., care observer sergeant.
Waters, George, Memphis, Tenn., care observer sergeant.
White, Clara, Memphis, Tenn., care observer sergeant.
Wells, Eddie, Memphis, Tenn., care observer sergeant.
Wright, George, Memphis, Tenn., care observer sergeant.
Wright, Ella, Memphis, Tenn., care observer sergeant.
Winston, Irene, Memphis, Tenn., care observer sergeant.
Washington, Lucy, Memphis, Tenn., care observer sergeant.
Walter, J. E., Leavenworth, Kans.
Wagg, G. M. D., Clay Centre, Clay County, Kansas.
White, Arthur L., Life-Saving Station No. 6, North Carolina.
Weber, George W., Chicago, Ill., No. 287 Orchard street.
Wilkinson, E. W., California, Hamilton County, Ohio.
Williams, Rev. C. F., Hoffman, Maury County, Tennessee.
Waite, Lieut. H. De H., Fort Washakie, Wyo.
Yates, T. P., Factoryville, Tioga County, New York.
Young, A., Troutdale, Grayson County, Virginia.

SIGNAL OFFICE, WAR DEPARTMENT.

SIGNAL SERVICE NOTES

No. X.

REPORT ON

LADY FRANKLIN BAY EXPEDITION

OF 1883.

PREPARED UNDER THE DIRECTION OF

BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,

CHIEF SIGNAL OFFICER OF THE ARMY,

BY

ERNEST A. GARLINGTON,

1ST LIEUT., 7TH U. S. CAVALRY, ACTING SIGNAL OFFICER.

BY AUTHORITY OF THE SECRETARY OF WAR

WASHINGTON CITY:
SIGNAL OFFICE.
1883.

United States - Signal Service.

SIGNAL OFFICE, WAR DEPARTMENT.

SIGNAL SERVICE NOTES

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WASHINGTON CITY:
SIGNAL OFFICE.
1883.

1884, [illegible] 12.
[illegible]
U. S. Signal [illegible]

NOTE.

This note is published for the information of those interested in research in the Arctic regions.

Ordinarily, the letter of transmittal of the Chief Signal Officer would have preceded the report of the officer in command of the supply expedition; but, as that letter contains questions that are answered in Lieutenant Garlington's supplementary report, it has been deemed best to print the papers chronologically.

LADY FRANKLIN BAY EXPEDITION.

REPORT OF LIEUTENANT GARLINGTON.

WASHINGTON, D. C., *October* 2, 1883.

CHIEF SIGNAL OFFICER, U. S. A.

SIR: I have the honor to report that, in obedience to par. 7, Special Orders No. 129, c. s., A. G. O., and Instructions from your office (appended and marked "A," with four enclosures and memorandum), I left Washington City on the 11th of June, 1883, and proceeded to New York, thence by United States steamer "Yantic" to Saint John's, Newfoundland, where I arrived on the 21st of June, without incident worthy of notice. I learned from the United States consul, Mr. Malloy, who came aboard almost immediately after the ship arrived, that the stores that had been shipped from New York on the 7th of June, on the steamer "Alhambra," had arrived and had been turned over to Captain Pike, master of steamship "Proteus," which had been previously chartered for the expedition. As soon as possible I went ashore, and visited the "Proteus," then lying at her wharf taking in cargo.

Everything was already on board, except the house and stores left at Saint John's from the expedition of last year. In order to get at the meteorological instruments necessary to carry on the work called for by my instructions, a large portion of the cargo had to be broken out; this was done on the 22d of June. Captain Pike reported that he would be ready to go to sea at the end of a week.

I then proceeded to get together the stores at Saint John's, which had been previously ordered by letter. Many of the articles thus ordered were not as good as they should have been, but it was then too late to replace them, so they had to be taken. I found that Consul Malloy had not secured the services of the three native "sealers" as you supposed had been done. As all the best of these "sealers" had made their arrangements for the summer at the fisheries, I found it very difficult to get anyone suitable for the service; however, after several days, I succeeded in shipping three men, who proved to be very good and reliable.

While in Saint John's, Lieut. J. C. Colwell, U. S. Navy, at his own request, strongly recommended by me, was detailed for duty with the relief expedition, and reported for duty the 23d of June. On the evening of the 28th, Captain Pike reported ship ready to leave the wharf, my detachment went aboard, the ship dropped out into the harbor and anchored.

As a result of a consultation with Commander Wildes, the agreement was entered into, which is hereto appended and marked "B."

At 4 o'clock p. m., the 29th of June, the steamships "Yantic" and "Proteus" steamed out of the harbor of Saint John's for Godhavn.

The day was beautiful, the wind was blowing a gentle breeze off shore. After clearing the narrows, the "Proteus" set her course close into shore; the "Yantic" set sail, and went more to eastward; we lost sight of her at 7.30 o'clock p. m., and saw her no more until she reached Godhavn.

On the morning of the 1st of July several icebergs were sighted, and during the day we passed several small pans of floe ice, also many scattered pieces of ice.

At 5 o'clock p. m. the same day, in latitude 53° 50′ north, longitude 52° 51′ west,

a large field of floe ice was sighted ahead, extending to the southward and eastward; we therefore altered our course slightly and ran into more open water. The ship was now forced through a large field of broken ice, very hard and blue in color, of peculiar forms and shapes, generally with flat tops, one-half to three-quarters under water, deeply washed horizontally, with long, projecting, shelf-like sides extending outward and downward into the water.

At 11.20 p. m., on the night of the 1st of July, we had to lie alongside very heavy ice for five hours, on account of an intensely dense fog. At half-past four o'clock a. m., on the 2d, we were again under way, and at 11 o'clock were clear of ice, after doing a little butting.

At 11 o'clock p. m. the temperature of the water was 33° Fahr. at the surface; the minimum temperature of the atmosphere during the night was 31° Fahr. On the morning of the 2d of July much ice was seen from aloft to the southward and eastward, but we soon lost sight of it, and no more floe ice was seen south of Disco, although many icebergs were passed.

On the night of the 4th of July the sun went below the horizon for the last time during the month. On the night of the 5th, at ten minutes to 12 o'clock, the sun touched the horizon, and, after an instant's apparent rest there, started on its upward course.

The coast of Greenland, very high and snow-capped, supposed to be old Sukkertop, was sighted at quarter of one o'clock on the afternoon of the 5th. Disco island was sighted at 11 o'clock on the morning of the 6th, about fifty miles to the northward.

Owing to some error in his bearings, the captain ran by the entrance to the harbor of Godhavn, and was making about due course for Ritenbenk, when some one on deck discovered a small boat several miles astern of us, evidently endeavoring to attract our attention. The ship was put about, and, after steaming five or six miles, came up to the boat, which proved to be the pilot boat from Godhavn. The pilot came aboard and showed Captain Pike the way in. We were anchored in harbor at 7.30 p. m. I immediately went ashore, and was very courteously received by Governor Djurhuus, from whom I learned that the inspector, Herr Andersen, was at Egedesminde, not having as yet changed his residence to Godhavn. He also informed me that no skin clothing had been prepared for this expedition at Godhavn, for the reason that he had received no instructions, and for the same reason he could not furnish me the Eskimo dog drivers, whom I expected to secure here. He could not tell me whether the inspector had received such instructions, so I determined to go to Egedesminde, as it was necessary for me to see him in person.

Governor Djurhuus very kindly offered to accompany me, and accordingly the next day we got the ship under way and proceeded to that settlement. The ship was steamed into harbor, no soundings being taken, and the anchor let go in three fathoms of water. In a few minutes she swung around and grounded under her stern; a warp was run out from the starboard quarter and the ship was pulled clear without much difficulty. I found the inspector absent on his annual tour of inspection, and as Godhavn was included in that tour, and the probabilities were that he would reach that place in a few days, I returned at once to await the arrival there of the "Yantic" as well as the inspector. At Egedesminde, I learned from the governor there that the inspector had, as far as he knew, received no instructions whatever in regard to an expedition from the United States. This was discouraging, as I knew it would then be impossible to procure skin clothing in any quantity, and I apprehended some difficulty in procuring the services of two Eskimo dog drivers in the absence of instructions from the home government.

From the 7th of July until the 16th I remained in the harbor of Godhavn, the crew being engaged in shifting cargo, filling coal bunkers, and generally trimming

ship. My own men were employed in preparing stores for forming depots as ordered (four of these were prepared of two hundred and fifty rations each), moving stores so as to be easily accessible in case of having to abandon ship, airing skin clothing, and getting alongside stores which had been left here by the expedition of last year.

Herr Andersen, the inspector, arrived on the afternoon of July 12th. I immediately called upon him, and through Governor Djurhuus, (the inspector speaking no English) learned that no instructions had been received by him in reference to an expedition from the United States. He, however, said he would gladly do all in his power to further the success of the expedition; that it was of course too late now to procure clothing, but that he would furnish two strong and reliable Eskimo, one of them from Godhavn, the other from Disco fjord, which we would pass on the way north, and could stop there to take him on board. This was satisfactory; the failure to get skin clothing was of no great consequence, as I already had a large supply.

The "Yantic" arrived at 7.15 p. m., the 12th of July. She had come all the way under sail and had encountered no ice at all. Commander Wildes informed me that he would remain there probably a week to repair the ship's boilers, then go to the coal mine in Waigatt strait and mine and get aboard about one hundred tons of coal. He subsequently told me, before leaving Godhavn, that he had succeeded in procuring from the inspector an order for thirty tons of coal from Ritenbenk, and that he would call there for it.

At 1 o'clock a. m., of the 14th, Nordenskjold's steamer, the "Sofia," arrived and left for Ritenbenk the next morning. She was to land a portion of her scientific party on Disco island, put on coal at Ritenbenk, then proceed to Cape York and remain there thirty days. While here they procured the services of Hans Christian for the Cape York party.

On the afternoon of the 14th the Eskimo dogs were gotten on board (twenty-one in number), and placed in a pen on deck, the Eskimo Nicholas taking charge of them.

I determined now to proceed north without further delay. The time necessary for repairing the boiler of the "Yantic," and the additional delay in procuring coal, would be longer than I deemed justifiable in further delaying my progress north. I therefore determined to leave Godhavn as soon as the state of the weather warranted. Outside the harbor it had been thick and threatening since the 12th of July, and Captain Pike did not think it prudent to put to sea. On the morning of the 16th the fog lifted, and at 6 a. m. the ship was under way, intending to call at a small settlement about fifteen miles up Disco fjord to get the other Eskimo whose services had been secured for the expedition.

The inspector and also the governor of Godhavn both assured me there would be no difficulty in reaching the settlement with the ship, and that Nicholas, the Eskimo, was perfectly acquainted with the fjord. At 8 a. m., when abreast of a small island lying on the eastern side of the entrance to the fjord, and which we had to round in entering, the mate reported shallow water ahead. Captain Pike thought there was plenty of water, calling attention to several icebergs ahead as evidence of the fact (these proved to be aground), but took no precaution to ascertain the depth of water by sounding. He caused the ship to "slow down" to half speed, and almost immediately gave signal "astern full speed," but before she answered she struck about 'midships on the starboard side, made one or two jumps, and hung on her starboard quarters; she slewed around easily, and to the southward, and lay north and south with a slight list to the port side. There was a slight swell, causing the ship to bump several times. Lieutenant Colwell got several casts of the lead; over the starboard quarter the line indicated five fathoms of water. He was nonplussed to account for the ship's striking in five fathoms of water, when one of the crew stand-

ing near told him that three fathoms had been cut from the lead line, so that in reality there were but twelve feet of water where she struck; soundings showed nineteen feet over the bow. When the ship hung, the engines were put ahead and astern at full speed, and in a few minutes she started, and with two or three jumps swung clear.

An examination was made by the chief engineer, who reported the main injection pipe cracked, but repaired it with canvass and white lead. A few splinters of wood floated to the surface, which were ground from her false keel as the ship swung on the rocks. The careless manner in which the ship was being navigated was thus again brought forcibly to my mind, and although I was determined not to interfere in the slightest way with Captain. Pike in his duties as master, I could not refrain from calling his attention to the matter, and insisting on more care in the future. After the ship was clear, wishing to take no more chances, I called away one of the whale-boats, and with Lieutenant Colwell, and crew of my own men, including the Eskimo Nicholas, started for the settlement in Disco fjord, which we reached after three hours' sailing.

I soon found the man designated by the inspector to accompany me, and Nicholas gave him the inspector's orders. In a few minutes he was ready to accompany us, with all his earthly possessions, a kyack and the skin clothing he had on his back. Before we could get out of the fjord a very dense fog set in, and it was with great difficulty that we finally got clear, there being so many inlets running from the fjord inland. However, I had made arrangements with Captain Pike to begin at 1 p. m. and fire his small swivel gun at intervals of fifteen minutes, and to sound the steam whistle at intervals of five minutes; so, after arriving within hearing, we experienced no further difficulty and reached the ship at 4 p. m. It cleared at 5 p. m., and the ship was under way again. Running around the southwest corner of Disco island, the course was set for Cape York.

On the morning of the 17th we passed Hare island, about forty miles to the eastward. Icebergs were numerous in all directions, as well as fragments, of all sizes, from those which had foundered. Saunderson's Hope was sighted at 6.20 p. m., fifty or sixty miles to the eastward. I was awakened on the morning of the 18th by being nearly thrown from my bunk, and upon looking through my port, saw ice in all directions.

I immediately went on deck, it being 6.30 a. m., and found that the ship was forcing her way through floe ice, the greater portion of which had the appearance of being very rotten and for the most part thin, varying from two to six feet in thickness; other portions, however, were very hard, blue in color, and from ten to twelve feet in thickness, showing manifestly the presence of Arctic ice. Scattered through this ice were numerous floe and icebergs of weird, fantastic shapes. On the top of the flat pans were numerous pools of water, which Captain Pike pronounced fresh. I procured a cup full and tested it with nitrate of silver, which showed that it contained salt.

He caused pieces to be broken from the highest points of the floe and put in the tank, which, when melted, were also subjected to the test, and it showed the precipitate at once, so I, therefore, ordered it to be used for washing purposes only.

The ship was stopped at 4.30 a. m., July 9th*, by an impenetrable pack. She was backed out and went south for a distance of eight miles, then a more easterly course was taken, and at 7.15 a. m. we sighted land, pronounced by Captain Pike to be Bushman island, with Cape York to the westward. We continued in a general easterly course working our way through the pack, hoping to find an open lead to the northward. At 4 p. m. the ship was brought to a standstill by the solid floe. Here I determined to lay until it was possible to get an observation for longitude, and thus

* This date was presumably the 19th.—Ed.

ascertain our true position. The pack was unbroken in all directions except to the southward. With an artificial horizon placed on the floe, Lieutenant Colwell determined longitude to be 61° 30′ W., Captain Pike proving to be entirely in error as to his position, and the land pronounced by him to be Cape York was, in reality, Cape Walker, and the island one of the Belgoni group. I was not surprised at the error made by Captain Pike, as he had no idea of what was the local deviation of his compass, which must have been great and variable for different courses, due to the large amount and unequal distribution of iron about the binnacle. At 7.20 p. m. the ship was turned south and made about twenty miles in that direction, when a lead to the west was discovered and followed, with many changes in course to keep in open water, making as much northing as possible. At 8 o'clock on the morning of the 20th we were again stopped by an impenetrable pack to the north and west.

The ship was again turned about and went twenty or twenty-five miles to the southward, when the course was changed to north and west through loose and rotten ice. Cape York was in sight all the afternoon.

At 7 p. m. we sighted Conical rock and steered directly for it. This island was passed at 1 a. m., the 21st, a few miles to the eastward. On this night young ice formed from the fresh water from the melting icebergs, as temperature of the water was only 31° Fahr. During the night and morning we passed through much loose ice and a large number of icebergs. At 9 a. m., 21st, Saunders' island bore abeam. We were within twenty miles of S. E. Carey island, but could not see it for the fog. At 11 p. m. we were stopped by the pack, and forced to retrace our course to the south, to find passage to the north and west, which was done when opposite Wolstenholme island. We were clear of ice at 12 p. m., and reached S. E. Carey island at 3 p. m., the cache of the "Nares' Expedition," being plainly in sight on the southwest end of the island.

As there was quite a breeze from the west, the ship passed around to the leeward of the island, and lay there while I, with Lieutenant Colwell, visited the cache, to leave a record for Commander Wildes in case he should reach this place, and to examine the condition of the stores.

I found everything there undisturbed. From a careful examination of two barrels of bread and three cans of meat, I estimated that sixty per cent. of the provisions are in good condition, while perhaps seventy-five per cent. could be eaten in emergency. The boat was also in good condition. I took a copy of the records of Lieutenant Lockwood of the Greely expedition, also a copy of the records of Sir George Nares, and left the original and my own record well secure under the boat. These copies were all lost in the wreck; the original record of Lieutenant Lockwood, afterwards furnished me by Commander Wildes, is appended, marked "C."

While on the island Lieutenant Colwell obtained a good observation for longitude, and his computation placed it more to the southward and eastward than now indicated on the chart. I saw several broods of young ducks, which indicated, according to Captain Pike, an early season in this region. I sent Artificer Moritz to the top of the island to examine the cairn, which he found as it had been left by Lieutenant Greely, and nothing was disturbed. The quantity and character of the ice encountered was interpreted as showing that a great deal had passed out of Smith's sound. At 7.20 p. m. we were under way, no ice in sight, steaming for Cape Alexander.

At 6 a. m., the 22d, we rounded the Cape and entered Pandora harbor. I went ashore to leave a record, (appended and marked "D") but I could not find the record left by the expedition of last year. The cliffs around the harbor were covered with birds, which kept up a deafening chattering.

The weather was perfect, calm, warm, delightful, and the hills were green with the pretty flowering moss of those regions, with occasional patches of grass of lux-

uriant growth. There was no ice as far as could be seen from the "crow's-nest" with the aid of a very powerful telescope.

I determined, if conditions continued the same, not to stop to leave a record at Littleton island, but to take advantage of the open water and auspicious circumstances, and push to the northward as far as Cape Prescott, where I had determined to make my first cache of provisions and to leave a whale-boat. We passed Littleton island at 9.45 a. m., the coal pile being plainly visible and apparently undisturbed. There was still no ice seen from the "crow's-nest," but at 10.30 a. m. it was reported, and at 11.30 a. m. the ship lay alongside of it. It presented an unbroken front—no leads to the north. I then decided to go to Cape Sabine to examine cache there, leave records and await further developments.

We reached Payer harbor at 3.30 p. m. I immediately landed Privates Ellis and Lamar, with magnetic and other instruments, thinking we would remain in Payer harbor long enough to get a set of observations.

I then, with a crew of my own party in one of the ship's boats, went to search for the cache of the expedition of last year, which I found after some difficulty. The tripod with flag marking the place had fallen down. Everything was in good condition except the boat, which bore marks of the claws of bears, a patch of lead having been pulled off; however, the damage was slight. The tarpaulin which covered the stores that could not be put under the boat, had been torn up by wild beasts. The tripod was placed in position and as well secured as possible. While the men were at work I examined the condition of the ice to the northward, and discovered that the pack had broken, and that open lanes of water had formed leading across Buchanan strait, along Bache island, and across Princess Marie bay as far north as a point of land which I took to be Cape Hawks and around it. After satisfying myself with the glass that there could be no mistake about the presence of a favorable lead, I started back to the ship, hurrying as rapidly as possible, appreciating the rapid changes in the condition of the ice and the treacherous movement of the pack. I reached the ship at 6.30 p. m., and at once got the observers aboard and told Captain Pike of the open way, and requested him to get under way and steam out of the harbor to make an examination of the leads and an effort to proceed north.

We were under way at 8 p. m. As we rouded Cape Sabine, at my request, Lieutenant Colwell took station in the "crow's-nest" with the mate. We proceeded through the open leads in the broken ice, which was very heavy, to within four miles of Cape Albert, when the ship was stopped about six hundred yards from the open water, which extended along the coast as far as could be seen from the "crow's-nest." Captain Pike thought the ship could be forced through, and entered a crack in the ice, and we accomplished about half the distance by "ramming." But after this the "ramming" was ineffectual, as the fragments of ice about the ship had become ground up so fine that when she backed out it would fill up the space immediately in front of the new fracture in the ice, and, as the ship came forward to ram, it acted as a cushion, which reduced her momentum to such an extent that when she struck the ice itself she had not sufficient force remaining to have any effect upon it. About midnight the attempt at this point was given up. A lead was found more to the eastward, in which the ship made fair progress until 2 a. m. the 23d, when we were jammed, and unable to move in any direction, within two hundred yards of open water. The ice here was not so heavy as it was in the position left at midnight, and Captain Pike pronounced the ship in no danger on account of its yielding nature. Soon after, at 5 a. m., the ice immediately in front separated, and we were in the open water which had been in our immediate front the night before. On arriving within four miles of Cape Albert, it was discovered that the open lane of water seen the night before had disappeared, and that the solid pack now held its place.

The attempt to proceed north was then relinquished for the time, and the ship was turned to the southward to make its way out of the pack. We proceeded in that direction until 11 a. m., when the ice closed in and effectually checked further progress. The ship was held here until 1 p. m.; the ice was much broken, and there was no danger of a "nip." As soon as it was possible, we started and made good progress for some time by frequently changing course and following the most favorable leads.

The large pans of ice which the evening before were passing to the southward, were now being brought back by the tide. Buchanan strait was rapidly filling up from the same cause. About 2.45 p. m. the ship was brought to a standstill within four hundred yards of open water, and movement in any direction was impossible. She was lying east and west. The ice in front and along the crack we were following immediately began to show signs of enormous pressure. The ship was in a most dangerous situation, and I realized that we would have a veritable "nip." I called my men quietly, and at once put them to work getting stores ready to be thrown on the ice at the first evidence of the ship sustaining serious injury. The "Neptune" had been beset in very nearly the same position last year, but had withstood the strain, rising three feet, and had gotten clear without damage. I hoped that the ice floes would ease or part before doing their fatal work. The pressure against the ship's sides was incalcuable, the heavy ice, from five to seven feet in thickness, as it came against her sides under this powerful strain, broke and rafted up on the floe amidships and astern, but still there were no signs of giving way. I yet hoped that the pressure would cease. At 4.30 p. m. the starboard rail gave way with a crash.

At this time I was in the "main hold" with part of my detachment getting out provisions; another detail, under Sergeant Kenney, was in the "fore peak" getting out the prepared depots. Lieutenant Colwell came to the "hatch" and told me that the bulwarks had given way, but that he thought the "nip" was easing. I requested him to look after getting the boats clear. About the same time Sergeant Kenney reported the depots on deck. Almost immediately after there was another loud crash; the ice had forced its way through the ship's side into the starboard coal bunker.

The deck planks began to rise and seams to open out. I at once set the men to work throwing provisions overboard as rapidly as possible. I observed that many of the boxes were going under the ship's side as they were thrown over on the starboard side, and two men were sent on the ice to move them farther on this floe as they came over, but this they could not do rapidly enough, and about thirty per cent. of the stores thrown over went under.

All the stores on deck and those near at hand in the hold were thrown overboard. Lieutenant Colwell was at this time getting the boats on the ice. The dingy and the starboard whale-boat were gotten off without much difficulty; a small hole, however, was stove in the whale-boat. There was now much water in the hold, and prevented more provisions being taken out. I now turned my attention to getting those stores already on the ice to a place of safety, and taking my detail proceeded to remove the boats and provisions to a safe distance from the ship, as I feared that when the ship would go down she would keel over to one side or the other and break the ice for some distance from her sides. Lieutenant Colwell was still at work on the port whale-boat, which was jammed and resisted all efforts to move it. The ship began to settle, the alarm was given "she is sinking." All hands on the ship then left her, but she settled only a few inches, and there appeared to be in no immediate danger. Lieutenant Colwell then went back to the whale-boat, and the detail, assisted now by the engineer of the "Proteus," Mr. Carmichael, and the boatswain of the "Proteus," Mr. Taylor, succeeded in getting it from the gallows frame, but here it stuck hard and fast between the ice and the ship. The pressure

fortunately eased a little on that side, and with the assistance of axes the boat was cleared.

The chronometers, sextants, and records were gotten out of the cabin and safely placed on the ice by Privates Ellis and Lamar. At 6.50 p. m. those who were still on the ship, saving whatever they could, left her, Lieutenant Colwell leaving last. At 7.15 p. m. she began to sink, and slowly passed out of sight on an even keel. One boat and a large quantity of stores were on the floe which had been on the port side of the ship, and it was necessary to get them on the other floe with the rest of the stores, and to move those already there, the ice showing signs of breaking where they were. Two boats' loads were successfully ferried over through the broken ice, the floe rapidly passing to the eastward. The line gave way and another boat could not be sent back. Lieutenant Colwell and party, who were on that side attending to the transfer, had by this time floated three-fourths of a mile away. They took what they could carry, and walked on the floe to a point opposite our position.

The dingy was sent and brought the party over. By this time more water had made and Private Murphy took Nicholas, the Eskimo, in the dingy, and by going about a mile and a half reached the point on the other floe where the stores were, and succeeded in bringing over one load, Nicholas having secured seven dogs. The dogs had scattered in all directions over the ice after being thrown over the ship's side, and, with the exception of those caught by Nicholas, ran off. Sergeant Kenney, with three men from the "Proteus," whose bags were on that side, also made a successful trip in the ship's "punt" through a lead which had now formed more to the eastward. I then proceeded to get things ready in case we had to suddenly quit the floe.

The services of Lieutenant Colwell during this trying time cannot be overestimated; but for his courage and presence of mind one of the whale-boats would have been lost, which would have seriously embarrassed, if it did not prevent, a successful retreat. Dr. Harrison is also deserving of commendation for zeal displayed in saving provisions, clothing, &c. The men of my detachment worked as I never saw men work before, and were as cool and collected as if it were an every day exercise. With the exception of the chief engineer of the "Proteus," Mr. Carmichael, and the boatswain, Mr. Taylor, none of the crew lent any assistance to me in saving property. At the first alarm those on duty abandoned their posts and all rushed to look after their own property in the forecastle, and did nothing toward saving provisions until after their bags had been packed and safely put on the ice. As soon as the stores began to go over the ship's side, they commenced to appropriate anything that suited their fancy. Boxes were broken open and rifled, bags of private clothing were opened and contents stolen. Lieutenant Colwell lost all of his clothing after it had been thrown on the ice; he afterward recovered a portion of it from the possession of one of the assistant engineers of the ship. The crew, with two or three exceptions, seemed bent on robbing from the start, and appeared to think it a matter of right that they should have any and everything they wanted. I think, however, that if their own officers had taken the proper stand, there would have been no difficulty in preventing the carrying into successful prosecution their stealing propensities. I protested to Captain Pike against this outrageous conduct; he admitted it, but said he was powerless to prevent it, saying: "they (the crew) are the worst lot of scoundrels I ever saw." The men of the crew were, of course, shipped under the English law for an English ship. They claimed that, as their pay stopped when the ship went down, their shipping articles were no longer in force, and that they owed no allegiance to the officers of the ship except what they choose to give. To assume control of the crew and to enforce disciplinary regulations necessary to a successful retreat from our perilous position, force would have been necessary, and more force than I had at my command. To avoid this, as well as any

resulting complications, I determined to keep my men and stores separate and distinct, avoiding, if possible, any unnecessary collision, and, if a retreat to the southward should be decided upon, I would sail in company with and give to Captain Pike and his crew all assistance consistent with the safety of the whole party. I called his attention to the importance of saving all the provisions possible, and of abandoning all unnecessary articles. It was agreed that his men should be divided among his three boats, mine in two whale-boats, and that we should sail in company and work for the mutual good, the first objective point being the land. About 12 p. m. the chances looked quite favorable for making land. After consulting with Lieutenant Colwell, it was decided that he should take a whale-boat and make the attempt. As my own men were much exhausted and the crew of the "Proteus" were comparatively fresh, having done, really, little hard work during the day, I asked Captain Pike for a crew for the boat. In response to his call for men, only four signified their willingness to go.

Lieutenant Colwell succeeded in making land, and in cacheing the provisions about three miles west of Cape Sabine. They were secured as well as circumstances permitted, and covered with a tent fly. This cache consisted of hard bread, tea, bacon, canned goods, tobacco, and sleeping bags, estimated at five hundred rations. This cache was not disturbed again. Lieutenant Colwell returned at 2 a. m. I took one of the men who had been with him, launched the other whale-boat and started for the land, but, after going half a mile, found all approaches closed, so returned and pulled the boats on the floe. I then directed the men to make themselves comfortable, and get all the rest they could, and waited a favorable time for making another attempt. This occurred at 5 a. m. the 24th. At first I decided to launch all the boats and endeavor to reach the land, but after consulting with Lieutenant Colwell and Captain Pike, it was decided to send but one of my boats, and one of Captain Pike's. Soon after Lieutenant Colwell left, everything looked so favorable, and the pan we were on having begun to move to eastward, I determined to start at once; Captain Pike also started two of his boats at the same time. It took a long time to make the distance to Cape Sabine, as I had only two men who knew how to row. The boat came near swamping on the way over, by reason of the plug in the bottom having been worked out of its place by boxes rubbing against it. I immediately unloaded the boat, left a man to watch the stores (a part of the "Proteus" crew being already there), and started back to the floe, one of Captain Pike's boats also returning. I found that all approaches to the floe were cut off, and now having but three men, it would be impossible to handle the boat in the ice. I therefore returned to Cape Sabine, and Captain Pike's boat also returned. Lieutenant Colwell in the meantime had reached the floe, and at 9.30 a. m. returned to Cape Sabine, bringing eight of the crew of the "Proteus" besides ten of my own men. He reported great difficulty in getting out of the floe, which was rapidly moving out to the eastward. When, after many failures, he at last found an opportunity to quit the floe, it became necessary to leave nearly all of the stores, which he had been hauling about the floe with much difficulty, in order that he might be able to bring away eight men of the crew of the "Proteus," who had been left on the ice, against their most earnest protests, by the master and officers of that ship. It was impossible to launch the dingy, and it was left on the floe. Sergeant Kenney, Corporal Elwell, Artificer Moritz, and two men from the crew of the "Proteus" made another trip to the shore in the ship's "punt," and secured a load of provisions and clothing. Artificer Moritz brought back the dingy loaded, having pulled it alone for about four miles. None of the Eskimo dogs were saved. The ice was running very thick between the Cape and the floe, which was now passing away rapidly, and all further attempts to reach it were abandoned. At 12 o'clock m., the 24th of July, every one was on the rocks at Cape Sabine; the boats were then hauled up and made as secure as possible. An

inventory of the provisions showed about forty days' rations on hand. A large quantity of clothing, consisting of buffalo overcoats, fur caps and gloves, arctic overshoes, uniform clothing, and underclothing, &c., was cached on Cape Sabine.

The two sidereal chronometers were placed in this cache. Each man's allowance of baggage was fixed: one buffalo overcoat, one fur cap, one pair of mits, a suit of skin clothing, and two changes of underclothing. All were very much exhausted, and I decided to do nothing until the men got at least a short rest.

It rained lightly during the day, and towards evening a thick fog set in, which continued until the afternoon of the 25th. During the stay I visited Brevoort island, and left the record appended and marked "E."

The prime object of the expedition was now defeated; what was the best course to follow to be able to accomplish something looking to the relief of Greely was the great problem to be solved. To have gone north in small boats was altogether impossible, and therefore out of the question, and even had it been feasible would have been useless under the circumstances. If the "Yantic" should reach Littleton island or Pandora harbor, the question would become one of easy solution. I could get from her all the stores she could spare, including clothing, coal, and canvas, establish a station at Life-boat cove, remain there with two or three men, and send the rest of the party and crew of the "Proteus" to Saint John's. A sealer could then have been secured and sent north. But, could she reach Littleton island? This was the point I had to settle in my mind from my knowledge of the condition of the ice as I found it on my way north from Disco island, taken in connection with Commander Wildes' instructions as far as I knew them. The "Yantic" crew was large, about one hundred and forty men, had a limited supply of provisions, and was not at all adapted to contend against the ice. It had taken the "Proteus," specially built for ice navigation, three days to force her way through the ice in Mellville bay. The Commander of the "Yantic," as far as I was informed, had specific orders not to go into the ice, or to place his ship in any position which would risk having to remain in those regions during the winter. When the ice through which the "Proteus" had passed off Labrador was described to Commander Wildes, when I met him in Godhavn in July, he said he would not have put the "Yantic" in it if he had encountered it. And while I was confident that he would go to Littleton island, if he deemed it prudent and consistent with the safety of his vessel and crew, I did not believe he would succeed in getting through Mellville bay where we had met so much ice. But I also thought if the conditions had changed in Mellville bay in the meantime, and if the "Yantic" should cross and reach Littleton island, she would find my record, know of the disaster, and easily follow us along the coast and pick us up very soon; if she did not sight us on her way north. It was my honest opinion that the "Yantic" would not cross Mellville bay. I therefore determined to cross Smith sound at the first favorable opportunity and to proceed to the southward as rapidly as possibe, for the purpose of opening communication. There was a possibility of meeting relief at Cape York in the Swedish steamer "Sofia." I considered the chances of her crossing Mellville bay more favorable than those of the "Yantic," as she was smaller, properly equipped, and commanded by a master of extensive Arctic experience.

While on Cape Sabine I took a large quantity of clothing from the crew of the "Proteus," which they had taken from my supplies. They surrendered it with bad grace, notwithstanding that I explained to them the urgent necessity of leaving everything, not absolutely needed, for Lieutenant Greely's party. I afterward saw that they did not give up all they had in their possession.

It cleared somewhat on the afternoon of the 25th of July, and at 3.20 p. m. all the boats were launched and under way, the dingy being towed by Lieutenant Colwell's boat.

Crossing the sound, fog becoming thicker, the boats became separated. My two boats, after being worked through a string of ice along shore, at 12 p. m. put into a small cove just north of Life-boat cove. I determined to remain there until it cleared. It was then raining. It snowed and rained all night. It cleared up the next morning, and we left for Pandora harbor, stopping at Littleton island to leave a record (appended and marked "F"). Upon reaching Pandora harbor at 7.50 p. m., we found Captain Pike's boats there, they having arrived during the morning. In the same cairn which I made on my way north, I now deposited another record (appended and marked "G"). We were detained here until the afternoon of the 28th by fog. At 4.45 p. m. we got under way, heading for Northumberland island.

At Radcliff point we were stopped by fog, but could not land. As the fog lifted we put into Sontag bay, hoping to find a place to secure the boats; it was full of ice and icebergs, among which we felt our way carefully, going entirely around the bay without finding a suitable place. There were several traps along the shore of the bay, but no recent signs of Eskimo. Although the fog was very thick, it was necessary to go on. We reached Cape Saumarez before finding a place to haul up the boats. Having but two men in my crew at all versed in the management of a small boat, at this camp I asked Captain Pike to let me have one of his sailors, if he could recommend a good one. He willingly consented, and it was arranged that the boatswain, Taylor, should come the next morning. When morning came Taylor told me that the rest of the crew "were making so much fuss" he would have to remain with them, but finally, after some conversation, he decided to come, notwithstanding their objections. He remained with me during the remainder of the boat journey, doing good and faithful service. The next morning, the 29th, at 5.45 a. m., we were under way, and after a long, weary pull on the oars, reached Northumberland island at 7.10 p. m. We were delayed here by a strong easterly wind until the afternoon of the 30th. On this island were seen numerous signs of Eskimo, but all old. At 4.40 p. m. the wind subsided and allowed us to get under way, and the next morning we reached a point about seven miles north of Cape Parry, and were stopped there by the threatening outlook ahead. We were kept here two days by a heavy storm from the east, with snow.

After consulting with Lieutenant Colwell, I decided not to go to Carey island, as originally intended. He thought it would be extremely hazardous with our heavily laden boats. We left this camp at 8.30 a. m., August 2. When off Fitzclarence rock we ran into "slack ice," and through it the rest of the day. We landed on Saunders' island at 9.20 p. m., hauled up the boats, and made camp. There was a good deal of ice to the southward. On this island were numerous signs of Eskimo, from three weeks to a month old. There was also small igloos or huts, which had been inhabited at no very distant date. An Eskimo dog, with one fore foot tied up to his neck, was also seen. Some of the men found two oars, one marked "Active," the other "Polynia." We were delayed at Saunders' island one day by the fog and running ice.

I deposited a record in a prominent cairn (copy of it lost). The boats were launched and gotten under way at 5.30 p. m., of the 4th. After making about seventeen miles we were stopped by the ice at 12.30 a. m. The boats were hauled up on a convenient point of rocks. Here I picked up a piece of a thermometer; there were old signs of Eskimo. At this place we were delayed by rain, fog, snow, and running ice until the 7th of August. At 11 a. m., of that day, we got under way and ran through loose ice, which became closer as we proceeded, and very thick when opposite Potowik glacier.

The leads of water rapidly closed. Finally, about 5.45 p. m., when about three-quarters of a mile from Conical rock, all openings through the ice closed, and the boats were completely jammed. Every man was on the ice in an instant, and by

quick and heavy hauling all the boats were hauled up on a small pan of ice. After an hour's delay, a small lead to the southward opened, the boats were launched and worked through it by pulling and pushing. In a short time we reached Conical rock. The boats lay here while I went to the top of the island to make an examination of the condition of the ice to the southward. I discovered a lane of water following the general trend of the shore. Returning to the boats, we again started and proceeded with great care and caution. Several times the boats narrowly missed being caught between the moving pans. It was impossible to reach the land at any time. During the night there was frost, and young ice formed from one-quarter to three-eighths of an inch in thickness. We succeeded in making land at 10.30 a. m., of the 8th.

We remained here until the afternoon of the same day, when we launched the boats and made about five miles, when we were stopped by the ice about fourteen miles from Cape York. The boats were hauled up on shore and the ice almost immediately jammed into the shore, completely blockading us. The wind, which was from the east, and to which we looked to free us, completely subsided. The tide came and went out without changing the condition of affairs. We were now very near Cape York, with no immediate prospect of being able to get our boats in the water. It was very important to communicate with Cape York, for the purpose of finding out from the Eskimo there whether any ship was in that vicinity or whether any had passed north. It would be necessary to drag the boat for some distance on the ice, so I decided to ask Captain Pike for his "punt," a small, light, and strong boat, specially built for knocking about in the ice, to send on to Cape York with a small party. He consented to furnish the boat and three men. He met with some difficulty in getting men willing to go, but after some parleying one of his engineers and two firemen signified their willingness to go; Artificer Moritz and Nicholas completed the crew. Lieutenant Colwell took charge of the boat and left for Cape York 9.30 a. m., of the 9th. I instructed him to find out all he could from the Eskimo there, and if I did not join him within a reasonable time, to return. It began to snow at 11 a. m. and continued with occasional rain, until night. It then began to blow quite strong from the northeast, which drove the ice from the shore immediately in front of camp, but it still remained unbroken to the southward. Shortly after midnight an open lane of water formed, following the trend of the shore, and the boats were immediately launched. It became necessary to put into the land, after having made four or five miles, on account of a very strong head wind. After about three hours the wind moderated, and we were able to proceed. When about eight miles beyond Cape York, our attention was attracted by the report of a rifle fired on shore. We immediately steered for the point whence the sound proceeded, and in a few minutes arrived at Lieutenant Colwell's camp. The evening before he had discovered some natives on shore and had gone to communicate with them. He reported that the camp consisted of three men, four women and nine children, and that they were well supplied with blubber and birds. With the aid of Nicholas he learned from them that there was no ship in the vicinity at that time; beyond that he could ascertain nothing definitely. One of the men had seen ten ships going to the eastward, but whether that year or during his lifetime it was impossible to make out. A ship had stopped there at some time but when, that year or some previous year, it was impossible to form an idea. They remembered Hans Christian, but had not seem him for a very long time; so we knew the "Sofia" had not been there.

From them we understood that there was a large settlement farther up in Immelick bay, and that we could secure the boats there. Thinking that I might be able to find out something more deffinite in regard to passing ships, I determined to go on. We went about eleven miles and were stopped by the ice, which closed in rapidly and prevented our going further or returning. The boats were with difficulty

pulled up on the rocks. Very soon after we landed, several natives came down from the rocks. I found it impossible to learn anything further than that the large settlement was inland some distance, and that they were there only temporarily. There were ten or twelve men in this party, no women or children. They appeared kind and generous, giving away their blubber for fuel and offering birds for food. I gave them some hard bread and a few cans of meat. There seemed to be no scarcity of game, many reindeer bones, antlers, &c., lying about, and several large caches of the blubber of seal, walrus, and white whale were found among the rocks. The natives themselves were strong and healthy looking, comparing very favorably in appearance with the Eskimo of the more southern settlements. They have no boats or kyacks, and travel entirely by dog sledge. Their only weapon is a short spear; with this they kill all their game, including reindeer and polar bear. We now realized that it would be necessary to cross Melville bay in the small boats, and after consulting with Lieutenant Colwell it was determined to load his boat as light as possible, and to send him directly to Disco at the first favorable opportunity, and that the other boats should proceed to Upernavik, keeping as close into the land as possible, on the outside of the ice. This course was decided upon because it was thought that the "Yantic" would not remain at Upernavik for any length of time, owing to the insecurity of the harbor, and that there was a strong probability of her leaving Disco before we could accomplish the distance by following the more circuitous route, which was necessary for the more heavily loaded and less seaworthy boats. Lieutenant Colwell's instructions are appended, marked "I." We were delayed in that camp until the evening of the 12th, it having rained and snowed all the time. There was so much ice that it prevented the boats being launched at any time.

At 7. p. m., the 12th, a small lead having opened, the boats were put in the water and an attempt made to get out of the bay. We met with considerable difficulty, having at one time to haul the boats on the ice and drag them for some distance, but finally reached open water.

At 1 a. m., on the 13th, we landed very near the place where we had overtaken Lieutenant Colwell a few days before. At this point we were delayed until the 16th. The time was occupied in rigging the boats with weather cloths and wash streaks, under the supervision of Lieutenant Colwell. Sea anchors were also prepared and made ready to use at short notice. The bows of the two whale-boats, along the water line, were sheathed with tin to protect them from the young ice.

At 10 a. m., of the 16th, although still cloudy, the boats all left in company. At 1 p. m. we bade Lieutenant Colwell "good bye" and "good luck," his course taking him more to the southward. We made fair progress during the afternoon, and all night there was a heavy frost and frequent snow squalls.

On the morning of the 18th ice began to offer more obstruction to progress; there were large fields of it, but for the most part "slack." Icebergs were numerous. It snowed and rained at intervals during the day. The ice stopped us at 4 p. m., and it was necessary to retrace our course for several miles, then take a more southerly course. There was a heavy swell from the southeast all day; the wind increased towards night, and at 5 p. m. was blowing a half gale and snowing hard. The sea was very high, the wind still blowing from the southeast. It was extremely hazardous to keep the boats under way any longer, and they were made fast under the lee of a large iceberg. We remained here about an hour, when a large iceberg coming down upon us forced us to cut loose and seek another protecting berg. We lay on our oars among the ice, keeping under the lee of the larger pieces and out of their way until about 8 o'clock, when we succeeded in mooring the boats to a low berg. We remained here three hours, then the foundering of a very large berg in our immediate vicinity necessitated another move. We rowed about among the ice as best

we could for two hours, when we reached a floe-berg and made fast under the lee of it. This afforded us shelter until the morning of the 18th. It snowed hard all night during the night of the 17th; a soft, slushy snow, as bad as rain. There was also a heavy swell from the southeast. Finally, at 2 a. m. the 18th, the wind and sea moderated sufficiently to allow us to proceed on our course. After a hard drag on the oars all day we reached an island, supposed to be Thom's island, at 10.30 p. m. Here we landed and made camp, having been in the boats sixty-one hours. There were some very old signs of Eskimos on this island. At 9 o'clock next morning we were again under way. There was still much ice, but it was "slack;" icebergs also became more numerous. Many were foundering, and their hard fragments made it very dangerous navigation for small boats. We reached Browne's island on the morning of the 20th, and stopped there long enough to go ashore and prepare a hot meal. From a cairn on top of this the record of Sir James Ross, commanding ships "Enterprise" and "Investigator," was taken. (Appended and marked "K.") This cairn had remained undisturbed for thirty-five years. We left the island at 9 a. m. and steered for Red Head, then in sight. Very soon we found ourselves in a perfect labyrinth of icebergs of immense size, piled upon each other, and were continually foundering. My boat scarcely got from under one, over a hundred feet high, as it parted with the report of a 20-inch gun, making the water boil and seethe as it was ground into fragments. While endeavoring to steer the boat rapidly out of the way of a large piece of ice that day, Private Murphy lost his footing and went overboard. He was pulled into the boat without much difficulty, and experienced no ill effects from his arctic bath. At 9 p. m. we reached a group of small rocky islands, landed and made camp. It was now bright and clear for the first time since August 7th.

On the 21st Private Ellis got an observation, which put this island in latitude 74° 51′. At 12.45 p. m. we again started, weather continuing fine. There was a great deal of ice, but slack; also countless icebergs lying around the islands and along the shore. Large glaciers lined the whole coast, and the mer-de-glace extended as far inland as the eye could reach.

At 7.30 a. m., the 22d, we reached Baffin island, where we moored boats and landed to get breakfast. There had been long ago a large settlement of Eskimo on this island, as indicated by several ruins of stone igloos, and many old graves; also by large numbers of bones lying about. Some Arctic blueberries were found here, but not ripe. A thick heavy fog set in soon after arriving, and prevented further progress for the time. While lying here a very large berg, about three miles away, foundered with a tremendous report, and produced a wave that broke the boats of Captain Pike from their moorings. At 7.30 p. m. we started under sail and passed Cape Shackleton at 2 a. m. At 4 a. m. we saw a puff of smoke rising from an island ahead; it was evidently a signal. Heading for it, we soon distinguished people among the rocks. We landed and found a party of Eskimo from Tessuissak with a whale-boat. The man in charge, who belonged to Upernavik and talked a little English, turned over to me two bags of ship's biscuits and two cans of coffee. From him I learned that Commander Wildes had heard of our disaster and had sent a lot of stores, of which these were a part, to Tessuissak; that he had been sent to this point to keep a lookout for my boats, deliver the provisions, and pilot us to Upernavik. He had been on the island six days. We left this island at 7.55 a. m., and a few hours later reached the most northern of the North Greenland settlements, Ivitarsuk, but did not stop. At 2.30 p. m. we reached Tessuissak. Here I received a letter from Commander Wildes, dated August 13, at Upernavik, saying: "I shall remain here as long as prudent, and then proceed to the coal mine at Godhavn." Governor Klieman delivered to us the supplies which had been sent up by Commander Wildes; fifteen days' rations for thirty-seven men. I determined to proceed

to Upernavik, and although Captain Pike's men made some objection to getting under way before the next day, we all started at 6.10 p. m. We had a favorable wind and made fair progress, keeping inside the islands and piloted by the Eskimo from Upernavik, until we were stopped at 11.30 p. m. by the thickest fog I ever saw. After groping around in it for a short time we made an island, but could not land; so we lay under its lee until 7 a. m. the 24th. The fog then lifted sufficiently for us to proceed on our course. Hundreds of icebergs were in Kikertarsoak fjord, having been discharged by the Upernavik glacier.

At 11.30 a. m. we reached Upernavik to find the "Yantic" gone. Governor Elborg met me at the landing, and at once took me to his house and insisted upon my being his guest as long as I remained there, the minister, Mr. Christiansen, kindly inviting Dr. Harrison to become his guest. Governor Elborg, before my arrival, had a large comfortable house cleared out and ready for occupancy by my men and the crew of the "Proteus," also a house for storing my property. These he at once placed at my disposal. The boats were secured, stores housed and the men took possession of their new quarters. Governor Elborg informed me that anything in the way of clothing, rations, fuel, &c., that I wanted he would be too glad to furnish. I availed myself of his kind offer to the extent of getting some potatoes, tobacco, and coal. It was impossible for him to have been kinder, more obliging or more thoughtful of our comfort. Here I learned the first news of Lieutenant Colwell since he left me on the 16th; he had arrived the day before, the 23d, and almost immediately started for Disco, transferring his crew to a small schooner kindly furnished by Governor Elborg.

Governor Elborg gave me a letter from Commander Wildes in which he said: "The time has arrived when I think it a serious risk to keep this ship in this high latitude. It is necessary to obtain coal at the mine at Disco, and the uncertainty of the weather and insecurity of the anchorage at that place make it doubtful if we can do much there. I shall remain in Godhavn until about September 15th, not later, and then proceed home."

I decided to await here news from the "Yantic," and in case she did not return to Upernavik, to winter there with my party. The coast is very abrupt between Upernavik and Waigatt strait, affording no harbor even for small boats, and the passage across Omenak fjord in rough weather extremely hazardous, if not impossible, in open boats. While at Upernavik I inquired particularly as to how far north the Eskimo of that settlement and its dependencies had succeeded in going. There was no remembrance or legend, as far as could be ascertained, of any having gone beyond Cape Shackelton. No one at Upernavik knew anything of the old settlement on Baffin island described to the governor by me.

At no time within the memory of the oldest one of these people had they communicated with the Cape York Eskimo. This matter was looked into with a view to ascertain the feasibility of making a sledge journey to Cape York. I concluded it to be impracticable. I also examined into the report brought there by the Swedish steamer "Sofia," of the death or killing of the "Doctor" of Greely's party, at first interpreted as referring to Dr. Pavy, but afterwards thought to refer to the commander or leader of the expedition. It appears that Hans Christian claimed to have been told by the Cape York Eskimo, while he was there on the "Sofia," that the two Eskimo belonging to Lieutenant Greely's party had visited them, and had told them that the doctor of the party at Lady Franklin bay had been killed, his arms and legs cut off. There was another story purporting to have come from Hans Christian that the Cape York Eskimo had received their information from the natives living about Cape Ohlsen, who had received it from a party of white men on Littleton island. The records of former Arctic expeditions show that full reliance

cannot be placed upon the statements of Hans Christian, and I do not think, under the circumstances, that the least credit should be given to those which he makes now. There were no evidences at Cape Sabine, Littleton island, Life-boat cove, Pandora harbor, or other points visited by me that any one had visited that vicinity from the station of Lieutenant Greely, and I am confident that all sensational stories, which have been recently published in regard to himself and party, are without foundation in fact.

If any white men had come south from Lady Franklin bay as far as Littleton island, they would most certainly have left a record. It is not within the range of probability that the Eskimo belonging to Lieutenant Greely's party would have been sent or even allowed to come south alone, and it is quite certain that if they did reach the Eskimo settlements they would not have returned to Fort Conger. There are no Eskimo above Rensselaer bay, nor, as far as I have been able to learn, do they go farther north. The Etah Eskimo do not cross Smith sound, and there are no settlements on the west side. So the only possible means of communication would have been by a party from Fort Conger, and that there was no such communication is, in my opinion, certain.

The "Yantic" arrived on the morning of the 2d of September; Lieutenant Colwell had reached Godhavn on the 31st of August, (copy of his report appended and marked "L",) and Commander Wildes had at once started for Upernavik.

My own party and the crew of the "Proteus" were soon aboard, and 1 p. m. steamed out of the harbor for Saint John's, where we arrived on the 13th of September. As soon as possible I sent you the telegram notifying you of the fatal termination of the expedition, and I need scarcely add, General, the sending of that telegram was the saddest duty I had ever been called upon to perform.

Pursuant to telegraphic instructions, the "Yantic" left Saint John's on September 20th with myself and party on board, and arrived in New York on the 29th.

At Carl Ritter bay there are two hundred and twenty-five rations (Greely); at Cape Collinson two hundred and forty rations (reported by Lieutenant Greely); at Cape Hawks about fifteen hundred rations (reported by Lieutenant Greely); on Cape Sabine seven hundred and fifty rations, a large cache of clothing, and a whale-boat in a damaged condition; on a small island near Brevoort island an English depot of about two hundred and forty rations; at Cape Isabella, a whale-boat; and across the sound on Littleton island, a depot of two hundred and fifty rations, and six and one-half tons of coal. The next depot is on S. E. Cary island, consisting of at least eighteen hundred rations, and a whale-boat. This season there was game in abundance on both sides of Smith sound. On the small islands about Cape Sabine there were ducks and gulls, and from Life-boat cove to Cape York the shore and islands were alive with ducks, lummes, and auks.

About Littleton island we saw at least one thousand walrus and some seal; in Pandora harbor a white whale, and in the hills back of the harbor reindeer. There were also Arctic hare seen there and frequently afterwards along the coast.

At Cape Athol, Artificer Moritz thought he saw a herd of musk oxen at a long distance, but they are more likely to have been reindeer. There were reindeer bones and antlers at each of the old Eskimo camps visited. The natives at Cape York reported reindeer very numerous about that place. I am of the opinion that if Lieutenant Greely should reach Littleton island this season he will divide his people among the different Eskimo settlements, and the stores he will find on his line of retreat, supplemented by the game of that region, will be sufficient food for his party during the coming winter. Unless the condition of the ice permits Lieutenant Greely to leave Discovery harbor in his boats, I do not think he will attempt the journey to Littleton island this season. Previous experience shows that a sledge journey in the fall of the year in that latitude is attended with so many difficulties

as to make it almost impossible. The attempt of the English expedition of 1875–'76 at fall sledging was abandoned in the face of insurmountable difficulties. I think that the experience of two winters will have shown to Lieutenant Greely the futility of making an effort to reach Littleton island by sledges in the fall. The conditions for sledging in the spring are much more favorable. He has at Discovery harbor a good house, plenty of fuel and provisions, with what game the country affords, to carry him to next spring. He could then start south as early as the state of the season permitted and reach Cape Sabine without much comparative difficulty. This will, in my opinion, be the course adopted by Lieutenant Greely, unless he has found Lady Franklin sound and Kennedy channel free of ice, which is improbable. I take great pleasure in calling attention to the very valuable services of Lieut. J. C. Colwell, U. S. Navy; to his professional knowledge is added great energy and determination, and a sound practical judgment, which qualities, with his experience of this year, eminently fit him for duty in the Arctic regions, and I earnestly recommend that his services be secured to command the relief vessel of the next expedition. The men of my detachment deserve the highest commendation for the cheerfulness and willingness with which they performed their onerous duties under the most trying circumstances, and I hope that the Chief Signal Officer will grant them such reasonable indulgence as they may ask.

I desire to call your attention to the manifest injury done me in the publication of certain statements immediately after the news of the disaster reached here. These statements purporting to have been authorized from the Signal Office, were to the effect that I had been furnished with "supplementary instructions," prior to my departure from the United States, which instructions I had positively disobeyed.

The only instructions I ever received are the original instructions published at the time. An unsigned written paper (with appendix "A" marked 5) was enclosed in the envelope with my instructions. This paper is simply an unauthenticated copy of a memorandum prepared in your office. I was informed that this memorandum was to have been furnished the Secretary of the Navy to form the basis of instructions to be given the commander of the vessel ordered to accompany the "Proteus;" when I found it among my instructions I at once carried it to you and called your attention especially to that clause, relating to landing supplies on Littleton island. You said, in substance, you did not know how that had gotten in there, and impressed upon me the necessity of carrying out, as far as possible, the instructions I had received. These instructions were based upon the letter of Lieutenant Greely (first enclosure of appendix "A"), and you called my attention to the fact that Lieutenant Greely strongly urged that the officer commanding the relief party should have no "latitude of action." The paper was not addressed nor signed, indeed bore no official marks whatever. I did not then nor have I at any time since regarded it as an order, and I was surprised to find the statement published that this paper was the "supplementary instructions."

I am very respectfully, your obedient servant,

E. A. GARLINGTON,
1st Lieut., 7th Cav., A. S. O., Commanding.

APPENDIX A.

WAR DEPARTMENT,
OFFICE OF THE CHIEF SIGNAL OFFICER,
WASHINGTON CITY, *June* 4, 1883.

Lieut. E. A. GARLINGTON, U. S. Army,
Commanding relief vessel to Lady Franklin bay.

SIR: You are aware of the necessity of reaching Lieut. A. W. Greely and his party with the expedition of this year. This necessity cannot be over-estimated as Lieut. Greely's supplies will be exhausted during the coming fall, and unless the relief ship can reach him, he will be forced with his party to retreat southward by land before the winter sets in. Such a retreat will involve hardship, and the probable abandonment of much valuable public property, with possible loss of important records and life.

For these and other reasons which will occur to you, no effort must be spared to push the vessel through to Lady Franklin bay.

In the event of being obstructed by ice in Smith sound or Kennedy channel, you are advised to try to find a passage along the west coast, which, besides being usually the most practicable, will afford better advantages for sighting and communicating with any party sent out by Lieutenant Greely. To make communication surer, your party must be able to readily send and receive messages by flag or heliograph and other means, and the necessary articles should be kept in readiness for instant use, when communication is possible.

Should the vessel be unable to get through the ice to Lady Franklin bay or to reach the west coast at points above Cape Sabine, it will be of great importance that Lieutenant Greely should know of the efforts being made to relieve him, and of the plans for doing so. You will endeavor, therefore, to convey such intelligence and omit no means of informing him or any of his party of the situation. Should any landings be made at prominent points on either coast during the efforts to get through the ice, you will leave a short record of the fact, with such information as it is desirable to convey, so deposited and marked as to render it discoverable by parties traveling southward. If such landings be made at points where caches of provisions are located, you will, if possible, examine them and replace any damaged articles of food, leaving, of course, a record of your action.

If it should become clearly apparent that the vessel cannot be pushed through, you will retreat from your advanced position and land your party and stores at or near Life-boat cove, discharge the relief vessel with orders to return to Saint John's, Newfoundland, and prepare for remaining with your party until relieved next year. As soon as possible after landing, or in case your vessel becomes unavoidably frozen up in the ice pack, you will endeavor to communicate with Lieutenant Greely by taking personal charge of a party of the most experienced and hardy men equipped for sledging, carrying such stores as is practicable to Cape Sabine, whence a smaller party, more lightly equipped, still headed by yourself, will push as far north as possible, or until Lieutenant Greely's party is met. In this and other matters you will follow closely the instructions of Lieutenant Greely, dated August 17, 1881, a printed copy of which is furnished you herewith. (Enclosure "1.")

The men not employed in these expeditions will lose no time in preparing the house for the whole party and in securing the stores preparatory to the arrival of Lieutenant Greely.

You will be furnished two observers and an outfit of scientific apparatus, and will be guided in their use by instructions herewith. The character and amount of the meteorological and other scientific work to be accomplished by your party is enumerated in enclosed memoranda marked B, C, D, E.

In addition to the medical officer and enlisted men taken from this city, you will employ three hardy ice-men at Saint John's, who have been already selected by the United States Consul there, under my direction, and in Greenland such Eskimo as you may require.

It is important that a careful and complete record of events should be made, and in case your party does not return this year that a full report be sent by the vessel on her return to Saint John's.

Each member of your party will be required to keep a private diary, which will be open to the inspection of the Chief Signal Officer only in case it should be necessary.

Whenever a junction is effected with Lieutenant Greely, you will report to him with your party for duty.

Should any important records or instruments have been left behind by Lieutenant Greely in his retreat, they may be recovered by the steamer to be sent in 1884.

It is believed that with the stores and supplies sent last year, which are at Saint John's, Newfoundland, and at the Greenland ports, a list of which is herewith furnished (enclosure "3") and which you will gather on your way northward, together with the provisions and articles supplied this year, everything needful will have been furnished for safety and success. I believe and expect that you will zealously endeavor to effect the object of the expedition, which is to succeed in relieving your comrades, since upon your efforts their lives may depend, and you cannot over-estimate the gravity of the work entrusted to your charge.

A ship of the United States Navy, the "Yantic," will accompany you as far as Littleton island, rendering you such aid as may become necessary and as may be determined by the captain of that ship and yourself, when on the spot.

With my best wishes for your success and the safe return of the united party,

I am, very respectfully, your obedient servant,

W. B. HAZEN,
Chf. Sig. Offr.

[Enclosure 1.]

FORT CONGER, GRINNELL LAND, *August 17th*, 1881.

CHIEF SIGNAL OFFICER OF THE ARMY.

SIR: I have the honor to recommend that in connection with the vessel to visit this station in 1882 there be sent some captain of the merchant service who has had experience as a whaler and ice-master. Five enlisted men of the army are requested to replace men invalided or who are found to be unfit otherwise for the work. One of the number should be a Signal Service sergeant. Sergeant Emory Braine, 2d Cavalry, and Sergeant Martin Hamburg, Company E, 10th Infantry, are recommended most highly, and without they are physically or morally unfitted within the year, their detail is requested. The two remaining men should be such as have had some sea experience. All the men should be rigidly examined as to their physical condition. The ice-master should be expected to see that every effort is made to reach this point by the vessel sent. In case the vessel cannot reach this point, a very possible contingency, a depot (No. "A") should be made at a prominent point on the east coast of Grinnell Land (west side of Smith sound or Kennedy channel) consisting of ninety-six cans chocolate and milk, ninety-six cans coffee and milk, one-half barrel of alcohol, forty-eight mutton, forty-eight beef, one keg rum, forty-eight cans sausage, forty-eight cans mulberry preserves, two barrels bread, one box butter, forty-eight cans condensed milk, one-half barrel onion pickles, forty-eight cans cranberry sauce, forty-eight cans soup, twenty-four cans tomatoes, one gross wax matches (to be in water-tight case), one-eighth cord of wood, one wall-tent (complete), one axe and helve, one whale-boat. At Littleton island, carefully cached on the western point, out of ordinary sight, with no cairn, should be placed an equal amount (Depot "B"), but no boat. A notice as to the exact locality should

be left in the top of the coal (preferably in a corked and sealed bottle), buried a foot deep, which was left on that island. A second notice should be in the edge of the coal furthest inland, and a third in the Nares cairn, now open, which is on summit southwest part of island.

The second boat should be left at Cape Prescott, or very near, in order that if boats are necessarily abandoned above that point one will be available to cross to Bache island and go the southward. These boats should be not exceeding forty feet and not less than twenty above high-water mark, and their positions should be marked by substantial scantling well secured and braced, to the top of which a number of pieces of canvas should be well nailed, so that it may be plainly and easily seen. A second staff, with pieces of canvas, should be raised on a point which shows prominently to the northward, so a party can see it a long distance. Depots "A" and "B" should be made ready in Saint John's, and be plainly marked and carefully secured.

The packages during the voyage should be easily accessible. Depot "A" should be landed at the farthest possible northern point. A few miles is important, and no southing should be permitted to obtain a prominent location. The letters and dispatches should all be carefully soldered up in a tin ease and then boxed (at Saint John's) and marked, or put in a well-strapped, water-tight keg, and should be left with depot "A," if such depot shall be at or north or in plain sight of Cape Hawks, and the newspapers and periodicals left at Littleton island. If depot "A" is not so far north, the letters and all mail should be returned to the United States. After making depot "B" at Littleton island, the vessel should, if possible, leave a record of its proceedings at Cape Sabine. If the party does not reach here in 1882, there should be sent in 1883 a capable, energetic officer, with ten (10) men, eight of whom should have had practicable sea experience, provided with three whale-boats and ample provisions for forty (40) persons for fifteen months. The list of all provisions taken by me this year would answer exceedingly well. In case the vessel was obliged to turn southward (she should not leave Smith sound near Cape Sabine before September 15th), it should leave duplicates of depots "A" and "B" of 1882 at two different points, one of which should be between Cape Sabine and Bache island, the other to be an intermediate depot between two depots already established. Similar rules as to indicating locality should be insisted on. Thus, the Grinnell Land coast would be covered with seven depots of ten days' provisions in less than three hundred miles, not including the two months' supplies at Cape Hawks.

The party should then proceed to establish a winter station at Polaris Winter Quarters, Life-boat cove, where their main duty would be to keep their telescopes on Cape Sabine and the land to the northward. They should have lumber enough for house and observatory, fifty tons of coal, and complete meteorological and magnetic outfit. Being furnished with dogs, sledges, and a native driver, a party of at least six (6) men should proceed, when practicable, to Cape Sabine, whence a sledge party northward, of two best fitted men, should reach Cape Hawks, if not Cape Collinson. Such action from advice, experience, and observation seems to me all that can be done to insure our safety. No deviation from these instructions should be permitted. Latitude of action should not be given to a relief party, who on a known coast are searching for men who know their plans and orders.

I am, respectfully yours,

(Signed) A. W. GREELY,

1st Lieut., 5th Cav., A. S. O. and Asst., Commanding Expedition.

A true copy:

LOUIS V. CAZIARC,

1st Lieut., 2d Art., A. S. O.

MEMORANDA OF DEPOTS CONTAINING SUPPLIES LOCATED IN SMITH SOUND AND KENNEDY CHANNEL.

Southeast Carey island.—One whale-boat and depot of provisions. (Expedition Sir George Nares, 1875.)

Visited in 1881 by Lieutenant Greely, and supplies reported in good condition.

Littleton island.—Six and one-half tons of coal on low ground, southwest side of island, facing Cape Alexander. (Greeley's expedition, 1881.)

Two hundred and fifty rations left in cache well secured. (Expedition, 1882.)

Cape Sabine.—Small depot of two hundred and forty rations (Nares' expedition, 1875) reported by Lieutenant Greely, but not visited by him.

Visited by expedition, 1882, and reported in good condition.

One whale-boat, one-eighth cord of birch wood, and two hundred and fifty rations left in cache well secured and covered. (Expedition, 1882.) August 31.

Cape Hawks.—Small depot, consisting of bread, two kegs pickles, two kegs rum, two barrels stearine, one barrel preserved potatoes. (Nares' expedition, 1875.)

Reported serviceable by Lieutenant Greely. (Expedition, 1881.)

Cape Collinson.—Small depot of two hundred and forty rations, (Nares' expedition, 1875) reported by Lieutenant Greely 1881, but cache not visited.

Carl Ritter bay.—Small depot of two hundred and twenty-five bread and meat rations on first bench from the sea, northeast part of the bay. (Lieutenant Greeley's expedition, 1881.)

Thank God harbor.—Depot containing supplies, amount and condition unknown. (Hall's expedition, 1874.)

Cape Isabella.—One whale-boat. (Expedition, 1882.)

Highest latitude reached by expedition of 1882, 79° 20′ north, August 10.

Highest point at which landing was possible, Cape Sabine, August 31, 1882.

[Enclosure 2—Memorandum A.]

INSTRUCTIONS FOR CLOSING SCIENTIFIC WORK AT CAMP CONGER.

1st. Before closing the station, have all thermometers and barometers carefully compared.

2d. Continue all meteorological observations on land to the latest practicable moment.

3d. Prepare for meteorological observations on the homeward voyage, by properly establishing on the vessel a marine and aneroid barometer and some thermometers, and have simultaneous comparative observations made on the vessel and on the land.

4th. Let the astronomical instruments on shore remain in place to the last practicable moment, and secure numerous comparisons of chronometers and determinations of time and azimuth.

5th. Shortly before sailing carry the chronometers carefully on shipboard, and make full comparisons between them and the ship's chronometers; also before sailing obtain as many determinations of time as possible by observations on the vessel. During the voyage maintain daily chronometer comparisons and observations of time, latitude and longitude by lunar distances. Stop on the Greenland coast and obtain special time observations for chronometric longitude on the meridian of some well determined station. On arriving at Saint John's, Halifax, and New York, make special time observations and comparisons with time-balls while in these harbors.

6th. During the voyage, maintain meteorological observations at 3, 7, and 11 a. m., and 3, 7, and 11 p. m., Washington time, and more frequently if possible. On arrival at New York make comparative simultaneous readings on the vessel, then

carry all the instruments to the army Signal Office, and compare them with the sub-standards at that station.

7th. Have the barometers and delicate thermometers brought carefully by hand to this office for further comparisons.

8th. Before leaving Camp Conger, all the thermometers used should be compared at the lowest possible temperatures, and in the following manner:

A mercurial thermometer should be selected as a standard of reference for temperatures as low as 30° Fahr. For holding the thermometers, a tin thermometer tester, with the perforated diaphragm knocked out, will suffice. When readings are being made, this should be placed with its contained liquid (brine or spirit) in an ordinary water pail, and the surrounding space filled with a mixture having nearly the same temperature as the liquid contained in the tin. The thermometers should not be allowed to rest with their bulbs on the bottom while being read, but should be held in the hand three or four at a time, and readings made after thoroughly stirring the liquid.

The spirit thermometers should be kept at the temperature to be compared for at least twenty minutes. For mercurial thermometers a much shorter exposure suffices; say five minutes.

A low artificial temperature can be obtained by mixing ice (or snow) and salt in the proportion of two parts, by weight, of ice, to one of salt. In making comparisons at low temperatures, this mixture should be put in the tin and around the tin in the pail. The mixture in the tin should be stirred thoroughly.

Comparative readings should be made at —6° Fahr., or lower, and at +2°, +12°, +22°, +32°, and +42°. The readings of all the thermometers at freezing-point should be noted. If the external temperature renders it possible to obtain comparisons below —6° the brine should be replaced with alcohol, whisky, or coal oil.

9th. You will provide, if possible, that the magnetic instruments and observers of Lieutenant Garlington's party be landed temporarily at Camp Conger, and a complete series of independent astronomical and magnetic observations be made by them, according to their own methods, including a comparison of chronometers, barometers, and thermometers, and determination of the bearing of your azimuth marks.

10th. Verify the dates of your calendars.

11th. Should your combined party be held in the ice at Camp Conger or remain during the winter of 1883 and 1884 at Life-boat cove, or at any other point, you will, as far as possible, continue the old, or make a new and complete series of, astronomical, magnetic, and meteorological observations, taking the precaution to check your work by independent determinations of important data by each of the methods in which your men have been instructed.

[Memorandum B.]

SCIENTIFIC OUTFIT OF THE LADY FRANKLIN BAY RELIEF EXPEDITION OF 1883.

1. 75-foot tape-line.
2. 2 tin thermometer testers.
3. 2 sextants.
4. 1 mercurial horizon.
5. 1 solid horizon and level.
6. 1 plumb line.
7. 1 pocket chronometer.
8. 2 marine chronometers (mean time).
9. 2 marine chronometers (sidereal time).
10. Charts of Smith's sound.

11. 4 thermometer shelters (cotton belt).
12. 12 ordinary stem divided mercurial thermometers.
13. 6 ordinary stem divided spirit thermometers.
14. 6 minimum stem divided spirit thermometers.
15. 6 ordinary stem divided spirit thermometers with cups and supports (for wet bulb).
16. 6 maximum stem divided mercurial thermometers.
17. 6 special-low minimum stem divided spirit thermometers.
18. 6 Yale minimum stem divided thermometers.
19. 1 Allnard dew-point apparatus, with bellows, and three long-stem low spirit thermometers.
20. 36 half-pint cans of ether.
21. 6 Signal Service water thermometers, and three cases.
22. 2 Koppe's hair hygrometers.
23. 2 pairs Arago-Davy conjugate thermometers.
24. 2 pairs Violle conjugate bulbs, with supports.
25. 2 mercurial marine barometers.
26. 2 mercurial cistern barometers and leather cases.
27. 4 extra glass barometer tubes, cisterns, and bags.
28. 4 extra attached thermometers.
29. 40 pounds pure mercury.
30. 2 aneroid barometers.
31. 2 single self registers for anemometers (Gibbon).
32. 1 small wind vane.
33. 4 Robinson's anemometers (heavy pattern).
34. 4 extra anemometer cups.
35. 4 galvanized iron rain gauges.
36. 10 measuring sticks (six snow and four rain).
37. 10 cells Eagle battery and 347 pounds copperas.
38. 100 feet cable for self register.
39. 2,000 yards insulated wire for telephone.
40. 8 telephones, viz, four transmitters and four receivers
41. 4 telephone call boxes.
42. 4 Le Clanche batteries.
43. 4 copper "grounds."
44. 10 dark lanterns (brass).
45. 150 blank books.
46. 12 blank daily journals.
47. 280 star charts for auroras.
48. 750 forms No. 102 for self register.
49. 1 tool chest (Signal Service).
50. 1 medicine chest.
51. Supply of wicking for lanterns.
52. 2 chamois skins.
53. 4 boxes pens.
54. 2 reams legal cap.
55. 4 reams letter paper.
56. 2 reams note paper.
57. 2 reams foolscap.
58. 4 quarts Arnold's ink.
59. 1 dozen capstan bars.
60. 1 reading glass.
61. 1 spool double silk fibre.

62. 1 bottle clock oil.
63. 2 universal awls.
64. 1 extra sun shade.
65. 1 bottle shellac.
66. 2 large brass lanterns.
67. 6 extra level tubes for theodolite.
68. 3 extra level tubes for dip circle.
69. 1 ream computing paper.
70. 120 copies form 101.
71. 750 copies form 120.
72. 50 copies form 113 *a*.
73. 200 copies form 117.
74. 50 copies form 127 *b*.
75. 50 copies form 132 *a*.
76. 50 copies form 132 *b*.
77. 50 copies form 140.
78. 10 copies instructions to observers.
79. 2 copies instructions to observers with latest corrections.
80. 10 copies card table for reduction to freezing.
81. 12 copies Signal Service Order 41, 1881 (dew-point tables).
82. 50 copies form 124.
83. 4 sets Signal Service property returns.
84. 10 sets Signal Service invoices and receipts.
85. 3 boxes paper fasteners.
86. 6 sets quartermaster's returns.
87. 650 sets pay-vouchers.
88. 1 ream heavy manila paper.
89. 2 spools red tape.
90. 1,000 envelopes.
91. 100 envelopes (white).
92. 100 sheets blotting paper.
93. 2 small blotters.
94. 12 gross rubber bands.
95. 12 dozen lead pencils (eight soft and four hard).
96. 2 dozen pen-holders.
97. 1 volume "Meteorological Record."
98. Material for magnetic observatory 10 x 10 x 7 feet, all wood with copper nails and brass hinges.
99. 20 pounds eightpenny nails.
100. 1 copy Treatise on Aneroid Barometers.
101. 1 copy Admiralty Manual of Scientific Inquiry.
102. 1 copy Arctic Manual, 1875.
103. 1 copy Vega's Logarithms.
104. 2 copies Nautical Almanac, 1883.
105. 2 copies Nautical Almanac, 1884.
106. 1 copy Chauvenet's Astronomy.
107. 1 copy Chauvenet's Triganometry.
108. 2 copies Loomis' Meteorology.
109. 2 copies Guyot's Tables.
110. 1 copy Everett's Deschanel.
111. 1 copy Bowditch Useful Tables.
112. 2 copies Negur on Chronometers.
113. 1 magnetometer with tripod.

114. 1 dip circle with tripod.
115. 1 altitude azimuth with tripod.
116. 2 marine glasses.
117. 1 record box, padlock and key.
118. 2 Grugan heliostats.
119. 2 cans, cases and straps.
120. 2 canteens and straps.
121. 2 extinguishers, foot.
122. 2 extinguishers, flying.
123. 2 flags, four foot, red.
124. 2 flags, four foot, white.
125. 2 funnels.
126. 2 shades, flame, foot.
127. 2 shades, flame, flying.
128. 2 pairs scissors.
129. 2 jointed staffs, complete.
130. 4 straps, small.
131. 2 torches, foot.
132. 2 torches, flying.
133. 2 pairs pliers.
134. 2 wormers.
135. 1 Webster's dictionary.
136. 1 tub for exposure of Arago-Davy thermometer.

[Memorandum C.]

INSTRUCTIONS AS TO OBSERVATIONS ON THE VOYAGE.

1. From the time of leaving Washington until your return you will, when at sea, determine your time, latitude and longitude, daily, unless the weather prevents.

2. Wind and compare together all the chronometers daily and keep them at as nearly uniform temperature as possible; in addition to the regular time observations you will compare the chronometers with the time-balls at New York, Halifax, Saint John's, &c., and with the chronometers belonging to the vessels; the care of the chronometers will be in accordance with the instructions published by Negur.

3. Regular observations of meteorological instruments and phenomena will be taken at least six times daily, namely: at 3, 7, and 11 a. m. and 3, 7, and 11 p. m., Washington time, and oftener, if practicable; this record will be maintained from the time of leaving Washington until you return. If, for any reason, the number of observations must of necessity be diminished, then at least the 7 a. m., 3 and 11 p. m. will be taken. Duplicate copies of all these should be made up daily for transmission to this office whenever opportunity occurs. Copies of the 7 a. m. observation on form 124 are particularly desired.

4. In order to execute these observations, you will carry by hand and keep with you the necessary sextants, chronometers, barometers, thermometers, &c., and will have them properly established on the vessel that carries you from New York and transferred to the search vessel on your arrival at Saint John's. When similar instruments are already in use on board of these various vessels, you will have proper comparisons made with these. Without in the least intermitting your own astronomical and meteorological observations, you will obtain complete copies of the logs and observations made by the officers of the vessels on which you may be, and make such notes as may explain any discrepancies as to dates and styles of records.

5. When at any port, if possible, you will either directly, or by means of an

intermediate portable barometer, make comparisons between your own and those used by meteorological observers in other cities.

The following is a list of stations where comparisons are desirable:

New York City Signal Service sub-standard.

Halifax, A. Allison.

Saint John's, Newfoundland, John Delaney.

Ivigtut, Greenland.

Godthaab, Greenland, S. Kleinschmidt.

Jacobshaven or Disco.

Upernavik, Greenland, Elborg (The Governor of the Colony).

Should you by stress of weather be driven to any of the meteorological stations on the coast of Labrador or to the German station in Cumberland sound, you will carry out similar comparisons.

6. Should you have occasion to stay for more than two or three days at any station on the Greenland or other coasts, you will have the magnetic apparatus carefully landed and secure one or more determinations of *declination dip* and *intensity*.

[Memorandum D.]

INSTRUCTIONS FOR LIEUTENANT GARLINGTON AT LIFE-BOAT COVE.

1. Should you be unable to reach Lieutenant Greely and be obliged to return to Life-boat cove and stay there during the winter of 1883–'84, you will, as soon as possible, erect the magnetic observatory, establish the instruments in place and maintain a series of observations in general accordance with the instructions heretofore issued by the International Polar Commission (see special orders 87 and 92, 1881), and those verbally given to your own observers.

2. The meteorological observations will be made as before at least six times a day, and, if possible, more frequently; the absolute magnetic elements will be determined several times during the day on the 1st and 15th of each month, and by each observer independently. Observations for true latitude and longitude by lunar distances will be made as often as necessary; tidal observations will be made daily through holes cut in the ice; special observations of auroras and other phenomena will be made as occasion requires.

3. Observations on the thickness of the ice, the currents and temperature of the water, its color and clearness, the nature of any sediment contained within it, as also the minute vegetable and animal matter; in short, whatever bears on the opening and closing of the channel, will be carefully recorded. Characteristic specimens of the water should be preserved in glass stoppered bottles.

4. One pair of Violle conjugate bulb, on short stands, and one pair of Arago-Davy conjugate thermometers (in the centre of the black iron tub), will be established side by side, about one foot apart, fully exposed to the sunshine and sky, and another pair of each, also side by side, but on long staves, about four feet above the ground, all will be read at each regular hour of observation (the Arago-Davy conjugate thermometers have, unfortunately, been made as maximum thermometers, and must be set after each observation as preparatory to the next one; they should be read both before and after setting). Experimental observations should be made as to the effect of covering the ground for several feet around and beneath these thermometers with sail cloth, furs, snow, &c.

5. The observations of heights of clouds, auroral arcs, &c., will be facilitated by establishing telephonic connection between two observers furnished with sextants, a short distance, say 1,000 yards apart. The distance of any terrestrial object may be similarly determined.

6. The effect of earth currents is to produce peculiar sounds in the telephone;

these may be observed by connecting the copper plates (that are to be buried in the ground or the water) to the ends of a line of about 1,000 yards long of insulated wire. Insert the telephones into the circuit and observe the sounds.

Record will be made at regular hours of the intensity and character of the noises heard in the telephones connected respectively with the north, south, east, and west lines. For further details you are referred to Special Orders 97 and 102 of 1881, and Instructions Nos. 72 and 76 and the appendices to the annual report, C. S. O., for 1881, all of which are herewith supplied.

7. Observations with Koppe's hair hygrometer will be made in accordance with the instructions of Goldschmidt and furnished herewith. The dry and wet hygrometer should be ventilated at all observations with a fan or hand-bellows. Observations of the dew-point, by means of the Allnard dew-point apparatus, will be made at least once a day.

[Memorandum E.]

1. If frozen in the pack ice of Smith's sound before reaching Camp Conger, you will maintain regular meteorological observations on or near the vessels as well as practicable.

2. The astronomical and magnetic instruments will be established on the pack ice and all special observations kept up as far as practicable; the instruments should, of course, be moved to the vessel on the least evidence of danger. If connection is opened with Lieutenant Greely and his party moves down to your vessel, he will provide that the independent observations by your observers be kept up with as little interruption as possible and that the proper comparisons with his instruments be made.

[Enclosure 3.]

LIST OF STORES AT SAINT JOHN'S OR CACHED.

Invoiced to Lieutenant Garlington by Lieutenant Craig, June 17th, 19th, and July 1st, 28th.

1,080 lbs pemican.
192 lbs sausage (2-lb cans).
200 lbs chicken (2-lb cans).
488 lbs mutton roast (2-lb cans).
100 lbs turkey (2-lbs cans).
Value in army rations 2,060.
288 lbs okra (2-lb cans).
240 lbs whortleberries (2-lb cans).
60 gals. lime juice.
50 lbs dried cherries.
24 bottles horse-radish flour.
60 gals. rum (½ bbls).
408 lbs squash (cans).
*384 lbs blueberries (2-lb cans).
600 lbs carrots (2-lb cans).
600 lbs turnips (2-lb cans).
162 lbs chocolate.
*300 lbs extract coffee.
60 gals. cider (¼ bbls).
*250 lbs peach butter.
250 lbs pear butter.
250 lbs plum butter.
40 pairs drawers.
150 pairs Iceland hose.
25 pairs S. S. boots (soled).
50 pairs S. S. boots (unsoled).
49½ yards red flannel.
60 pairs cloth gloves.
50 pairs boots (gusset and b.).
10 seal skins.
6 tons dried seal meat.
240 fathoms Manila rope.
100 lbs oakum.
200 yds cotton duck.
3 balls twine.
2 tackle and vise.
2 whale-boats.
18 boat oars (14 feet).
2 sprits and sails.
2 barrels cement.
3,012 feet dressed boards.
1,494 feet clear boards.
2,517 feet pine.
170 pieces flooring.

* Blueberries (48 jars); ext. coffee (140 lbs.); peach butter (2 cases, 12 5-lb. cans) returned to N. Y. by error, and stored with depot C. S.

1,000 brick.
5 packages copper nails.
25 packages tacks.
2 gross screws.
10 lbs (assorted) staples.
½ cord wood.
160 gals. alcohol.
432 boxes wax matches.
2 hand lamps.
2 lanterns (B. and E).
100 gals. signal oil.
25 lbs gunpowder.
100 zinc battery.
1 theodolite.
1 sextant (small).
1 hygrometer.
100 lbs excelsior.
½ gal. clock oil.
15 large diaries.
25 small diaries.
4 S. S. P. returns sets.
10 S. S. I. and receipt sets.
30 S. S. pur. and ex.
60 Forms No. 52.
40 inserts.
10 Abs. D.
6 Ins. to O. S.
6 temp. tables.
24 rolls pins.
24 journals.
6 reams cap paper.
3 boxes paper fasteners.
6 sets Q. M. returns.
3 Army Reg.
650 sets pay vouchers.
3 Nau. Almanac.
50 Forms No. 101.
400 Forms No. 102.
50 Forms No. 113A.
1 met. record.
3 Ins. to Obs. S. S.
12 Forms 127 B.
6 Forms 132 A.
6 Forms 132 B.
30 Forms 140.
1 Travels in Siberia.
1 Schwatka.
1 Revenue cutter Corwin.
12 lbs. hektograph material.
120 collodion plates.
5 dry slate boxes.
2 Ger. Arctic Expedition.
1 Ger. Star Cot.
14 reams letter paper.
4,000 envelopes.
8 gross pens.
400 sheets blotting paper.
2 small blotters.
12 gross rubber bands.
3 steel erasers.
16 doz. lead pencils.
3 doz. pen-holders.
2 reams note paper.
1 ream wrapping paper.
3 rulers.
12 spools tape.
10 balls twine.
1,000 C. lined envelopes.
1 chart N. P., No. 278.
1 " " " " 2,177.
1 " " " " 235.
1 " " " " 2,117.
1 " " " " 2,282.
1 " " " " 2,118.
1 " " " " 2,382.
1 " " " " 276.
1 " " " " 274.
2 C. Polar charts.
1 nail puller.
3 hatchets.
2 oz. pyrogallic acid.
2½ lbs sal amoniac.
5 lbs sal soda.
6 lbs soda hyposulphate.
⅛ lb bromide potassium.
400 lbs sulphate copper.

[Enclosure 4.]

SAINT JOHN'S, NEWFOUNDLAND, *May* 26, 1883.

This agreement, made by I. & W. Stewart, owners of the good steamship "Proteus," burthen per register 467 tons net, or thereabouts, Richard Pike, master, parties of the first part, and General W. B. Hazen, now in Saint John's aforesaid, Chief Signal Officer of the Army of the United States of America, and acting on behalf of the Government of the United States, party of the second part, witnesseth:

That the parties to the first part agree that, in consideration of the terms hereinafter set forth, the said steamship or vessel being light, staunch, and strong, and in

every way fitted for the voyage hereinafter described, shall be ready for the said voyage and shall be at the disposal of the Chief Signal Officer of the Army of the United States from the fourteenth day of June, 1883, when the voyage shall be construed to have begun, and the said party of the second part hereby, in consideration of the aforesaid, contracts to pay for the use of said vessel for at least three and a half months at the rate of six thousand dollars ($6,000.00) per month of thirty days, in Newfoundland currency, at one and one-half per cent. premium, being difference of exchange; the said party of the second part further agrees that the said compensation shall be paid at the end of each month by draft on the office of the Chief Signal Officer, Army of the United States, the first draft to be made payable fourteenth of July, 1883.

It is also mutually agreed by the parties hereto that should the said vessel be detained on the said voyage beyond the time stipulated, then the same rate of six thousand dollars per month shall be paid for her until her return to Saint John's, Newfoundland, the said expenses to be paid at the end of each month as is herein provided for the payment of the compensation, and that, in the event of the loss or abandonment of said vessel, the party of the second part shall continue and pay the stipulated hire monthly until the arrival of any portion of the crew in Saint John's aforesaid.

It is further agreed by the parties of the first part to provide all necessary food and provisions for the force accompanying the relief expedition or returning from Lady Franklin bay, said food to be equal to the usual ship's fare and to be furnished at the rate of four dollars ($4.00) per week of seven days each, in Newfoundland currency, for each individual comprising said force, and the party of the second part agrees to pay for the food thus furnished at the same time, and in the same draft, that final payment is made for use of said vessel.

It is hereby further mutually agreed, that in the event of the force of Lady Franklin bay (Fort Conger, Discovery harbor) being in need of coal, the said parties of the first part will deliver to said force, or at points designated by the agent of the Chief Signal Officer, such quantity as may be needed to the amount of seventy (70) tons, at the rate of four dollars ($4.00) per ton, in Newfoundland currency, to be drawn for upon the return of the vessel to Saint John's.

It is agreed by the party of the second part, that persons constituting the relief force, shall render the captain and crew of the said vessel, all the assistance in their power to expedite the landing of supplies at all points where landing shall be made.

It is further agreed that Lady Franklin bay, (Fort Conger, Discovery harbor) is the extreme northern point which it is desired that the vessel aforesaid shall reach, but if the master of the vessel, and the officer or agent representing the Chief Signal Officer aforesaid, after consultation, shall agree that it is impracticable to reach said bay by reason of ice barriers, lateness of season, or any other insurmountable obstacle, then the said Richard Pike, master aforesaid, may leave Smith Sound (or the northernmost point attainable) to return to Saint John's aforesaid, not earlier than September 1st, 1883, and he shall discharge and cache stores, as may be required by the agent of the Chief Signal Officer aforesaid. The parties of the first part hereby agree that this contract shall be performed by them.

The act of God, the Queen's enemies, fire, and all and every other danger and accident of the seas, rivers and navigation of whatsoever kind and nature, always excepted. The parties of the first part further agree that they will pay to the agent of the Chief Signal Officer, army of the United States, as a penalty for non-performance of this contract, the sum herein agreed to be paid by the officer of the Chief Signal Officer aforesaid, for the use of said vessel for the period of three and a half months.

Signed, executed, and delivered at Saint John's, Newfoundland, this twenty-sixth day of May, one thousand eight hundred and eighty-three.

(Signed) W. B. HAZEN,
Chief Signal Officer, U. S. Army.
p. p. I. & W. STEWART.
J. SYME.

Witnesses:
(Signed) JAS. CODY.
THOS. MOLLOY,
[SEAL.] *U. S. Consul.*

A true copy:
LOUIS V. CAZIARC,
1st Lieut., 2d Art., A. S. O.

[Enclosure 5.]

The naval tender to join the "Proteus" at Saint John's, Newfoundland, and to proceed with her to the neighborhood of Littleton island.

The "Proteus" to land her stores, except supplies for more northerly depots, at Littleton island on her way north. If she succeeds in reaching Lady Franklin bay, to pick up the stores, excepting the house and depots, if possible, on her return. The naval tender will await the return of the "Proteus" at the neighborhood of Littleton island, and on her return steam to the south in her company, until she reaches the southern limits of the ice pack, when the vessels may separate. Should the "Proteus" be crushed in the ice, her crew will retire on Littleton island, and the tender will bring to Saint John's, Newfoundland, the officers and crew of the "Proteus." The rest of the party to remain at Littleton island. But should the ice render it dangerous for the tender to remain in the neighborhood of Littleton island until the "Proteus" returns, or her crew and the expeditionary force succeed in reaching there, the tender may go to the south, leaving full particulars at Littleton island.

Signals by flags, heliograph, and guns should be preconcerted, and communication by this means should be maintained between the two vessels as long as possible after they are separated by the passage north of the "Proteus."

Nothing in the northward movement must be allowed to retard the progress of the "Proteus." It is of the utmost importance that she take advantage of every lead to get to Lady Franklin bay.

OFFICE CHIEF SIGNAL OFFICER,
Washington, D. C., June 5, 1883.

[Copy.]

APPENDIX B.

MEMORANDUM OF AN AGREEMENT BETWEEN LIEUTENANT GARLINGTON, U. S. ARMY, AND COMMANDER WILDES, U. S. NAVY.

"Yantic" to proceed to sea with the "Proteus" and remain in company as long as possible. "Yantic" will proceed to Disco under sail, will leave letters for Lieutenant Garlington at Disco and Upernavik.

Cairns enclosing bottles or tins will be left at Cape York, S. E. Carey island, or Hakluyt island, Pandora harbor, and Littleton island. "Yantic" will remain in Pandora harbor not later than August 25, Disco not later than September 20.

Lieutenant Garlington to leave letters in Disco and Upernavik and records on S. E. Carey island, or Hakluyt island, Littleton island, and Pandora harbor if entered.

"Proteus" to endeavor to communicate with "Yantic" at Pandora harbor before August 25.

Should "Proteus" be lost, push a boat or party south to "Yantic."

Pandora harbor will be headquarters, but before departure "Yantic" will run up to Littleton island.

[Copy.]

APPENDIX C.

INTERNATIONAL POLAR EXPEDITION TO LADY FRANKLIN BAY, FITTED OUT BY THE WAR DEPARTMENT, UNDER THE SUPERVISION OF GENERAL W. B. HAZEN, CHIEF SIGNAL OFFICER UNITED STATES ARMY, AND COMMANDED BY 1ST LIEUTENANT A. W. GREELY, 5TH CAVALRY, A. S. O. AND ASST.

Left in the Steamship "Proteus," island off Upernavik, 7 p. m., July 29, 1881, and at 7 a. m. July 31, stopped by heavy fog about six miles south of land supposed to be Cape York. Middle passage taken and found to be entirely unobstructed by ice. All well. This notice deposited August 1, 1881.

(Signed) J. B. LOCKWOOD,
Lieut., 23d Inf., U. S. Army, 3d Officer.

[Memoranda.]

One keg of biscuits opened and found mouldy. One can of beef opened and found good. Stores generally found apparently in same condition as when deposited here in 1875.

(Signed) J. B. LOCKWOOD,
Lieut., U. S. Army.

COPY OF THE COPY OF THE RECORD OF SIR GEORGE NARES.

ARCTIC EXPEDITION, *July* 27, 1875.

H. M. S. "Alert" at Carey island.

Any one finding this depot of provisions and boat is requested not to appropriate it to their own use. The depot is deposited by the English Arctic Expedition of 1875, for use in the event of the crews of the ships having to travel south to Upernavik. The "Alert" and "Discovery" passed through the middle ice in two days. They leave for Smith sound at 6 a. m. this morning.

(Signed) G. S. NARES,
Capt. R. N., in command of the Expedition.

A true copy of the original taken this 1st day of August, 1881, by expedition under Lieutenant A. W. Greely, U. S. Army, for whose record see bottle herewith.

COPY OF ENDORSEMENT OF LIEUTENANT GARLINGTON

UNITED STATES RELIEF EXPEDITION,
4 p. m., 21st July, 1883.

Left Godhavn, Disco island, 16th July, 1883. Encountered pack 18th July in lat. 74° 40′, long. 61° 30′, steamed through it in various directions until fifteen miles south of this island. Open water to the north. Depot apparently same as left in 1881. Opened two barrels of bread; one spoiled, one a little mouldy, but eatable, and two cans of beef; one good, one spoiled.

E. A. GARLINGTON,
1st Lieut., 7th Cav., A. S. O., Commanding.

[Copy.]

APPENDIX D.

STEAMER "PROTEUS,"
United States Relief Expedition, 22d July, 1883.

At 6 a. m. we are rounding Cape Alexander, and will enter Pandora harbor to leave this record. No ice met between Carey island and this point, and none to be seen to the north from the "crow's-nest" with the aid of a powerful telescope. Weather perfect; if it continues I will go directly north and not stop at Littleton island to leave a record, for it takes but a very short time to change the aspect in these regions.

(Signed) E. A. GARLINGTON,
1st Lieut., 7th Cav., A. S. O., commanding.

[Copy.]

APPENDIX E.

UNITED STATES RELIEF EXPEDITION,
Cape Sabine, 24th July, 1883.

The Steamer "Proteus" was "nipped" midway between this point and Cape Albert on the afternoon of the 23d instant, while attempting to reach Lady Franklin bay. She stood the enormous pressure nobly for a time, but had to finally succumb to this measureless force. The time from her being "beset" to going down was so short that few provisions were saved. A depot was landed from the floe at a point about three miles from the point of Cape Sabine as you turn into Buchanan strait. There were five hundred rations of bread, sleeping bags, tea and a lot of canned goods; no time to classify. This cache is about thirty feet from the water line, and twelve feet above it on the west side of a little cove under a steep cliff. Rapidly closing ice prevented its being marked by a flag-staff or otherwise; have not been able to land there since. A cache of two hundred and fifty rations in same vicinity left by the expedition of 1881; visited by me and found in good condition, except boat broken by bears. There is a cache of clothing on point of Cape Sabine, opposite Brevoort island, in the "jamb" of the rock, and covered with rubber blankets. The English depot on the small island near Brevoort island in damaged condition; not visited by me. There is a cache of two hundred and fifty rations on the northern point of Littleton island, and a boat at Cape Isabella. All saved from the "Proteus." The U. S. Steamer "Yantic" is on her way to Littleton island with orders not to enter the ice. A Swedish steamer will try to reach Cape York during this month. I will endeavor to communicate with these vessels at once, and everything within the power of man will be done to rescue the brave men at Fort Conger from their perilous position.

The crew of the "Proteus" consisted of Captain Pike and twenty-one men; my own party of Lieut. J. C. Colwell, U. S. Navy, Acting Assistant Surgeon, J. S. Harrison, five enlisted men of the line of the Army, two Signal Service men, three Newfoundlanders and two Eskimo.

It is not within my power to express one tithe of my sorrow and regret at this fatal blow to my efforts to reach Lieutenant Greely.

I will leave for the eastern shore just as soon as possible, and endeavor to open communication.

E. A. GARLINGTON,
1st Lieut., 7th Cav., A. S. O., Commanding.

[Copy.]

APPENDIX F.

UNITED STATES RELIEF EXPEDITION,
Littleton Island, 26th July, 1883.

My party, consisting of Lieutenant Colwell, U. S. Navy, Dr. J. S. Harrison, seven enlisted men, U. S. Army, three civilian employés, and two Eskimo, arrived here at 5 p. m. to-day from a very rocky inlet above Life-boat cove in two whale-boats and having dingy in tow; very thick fog on way over and sea quite rough. Boats behaved admirably, considering the strains to which they have been put, dragging them over the floes, rocks, &c. This party was in the steamer "Proteus," of Saint John's, Newfoundland, chartered by the United States Government, going to the relief of Lieut. A. W. Greely, U. S. Army, at Lady Franklin bay, Grinnell Land. The steamer was crushed in the ice between Cape Sabine and Cape Albert, Bache island, on the afternoon of the 23d instant. All saved. Much provisions gotten over side of ship, but a great quantity went under before it could be removed a sufficient distance from the ship for safety. Five hundred pounds of hard bread, sleeping bags, and assorted subsistence stores were landed from the floe about three miles from Cape Sabine around point towards Bache island. There is also a cache, made last year, along same shore. The depot was secured as well as possible. Ice was rapidly closing, heavy, &c. A quantity of clothing was left on extreme point of Cape Sabine, and one barrel of beef—all poorly secured for same reason as above. I am making for the south to communicate with the U. S. steamer "Yantic," which is endeavoring to get up. Every effort will be made to come north at once for the Greely party. The "Yantic" cannot come into the ice, and she has a crew of one hundred and forty-six men. So will have to get another ship. Everything will be done to get as far north as possible before the season closes. Ice thick and heavy. Calm to-day, and I am in a great hurry to take advantage of it and tide.

(Signed) E. A. GARLINGTON,
1st Lieut., 7th Cav., A. S. O., Commanding.

[Copy.]

APPENDIX G.

UNITED STATES RELIEF EXPEDITION,
Pandora Harbor, July 27, 1883.

Arrived here at 7.50 last evening with two whale-boats and one dingy in tow, Lieut. J. C. Colwell, U. S. Navy, Dr. J. S. Harrison, seven enlisted men, U. S. Army, three civilian employés, two Eskimo, and self, composing party. Captain Pike, of the steamer "Proteus," and his crew (twenty-two men) are also in this harbor. The "Proteus" was crushed in the ice about six miles from Cape Sabine, magnetic bearing from Cape Sabine about S. by E. 1–2 E., on the afternoon of the 23d inst. All saved. I have forty days' full rations for my party. Will go south, keeping close into shore as possible, and calling at Carey islands, to Cape York or until I meet some vessel. Hope to meet U. S. steamer "Yantic," or the Swedish steamer "Sofia," which should be about Cape York. Weather since wreck has been foggy, and at times some rain, delaying progress very much. Party are well and in good spirits. Will leave here at 5 a. m. to-morrow; detained all day by fog.

E. A. GARLINGTON,
1st Lieut., 7th Cav., A. S. O., Commanding.

[Copy.]

APPENDIX H.

UNITED STATES RELIEF EXPEDITION,
Immelick Bay, Near Cape York, 12th August, 1883.

The steamer "Proteus," Saint John's, Newfoundland, Captain Pike, chartered by the United States Government to carry relief expedition under my command to Lady Franklin bay, Grinnell Land, was caught in pack six miles nnw., ½ w. from Cape Sabine, and was crushed, sinking at 7.30 p. m., on the 23d July, 1883. The crew and relief party all saved, and also about forty days' provisions for all hands, together with a lot of fur and other clothing. My party fitted out, and the rest left in a cache on the point of Cape Sabine. A cache of provisions and twelve sleeping bags left at a point along northern shore of Cape Sabine, about three miles from point of the cape. This cache contains about four hundred pounds of hard bread, canned meats, fruits, and bacon sufficient to make full load for whale-boat. A large quantity of stores went down under the sides of the vessel after being thrown overboard; much had necessarily to be abandoned on the floe, and it was impossible to secure all of it afterwards, although several boat loads were secured subsequent to leaving floe. The party made a landing on Cape Sabine on the morning of the 24th July, and remained there until the evening of the 25th, when the ice opened sufficiently to allow our leaving, but closed in almost before we got under way. Pike's men in three boats, my party in two whale-boats, Colwell's boat towing dingy.

We crossed Smith sound and made land just above Lfe-boat cove at 12.30 p. m. in a dense fog. Remained there until next day and made Pandora harbor at 7.50 p. m., which place Pike's boats had reached the night before; from that point we have come here, having been delayed by bad weather, fogs, and ice more than half the time. Just north of Conical rock we were "jammed" in the ice and had to drag the boats on a "pan." Things looked very dubious for a time.

From this point Lieutenant Colwell, with second whale-boat, goes direct to Disco, as it is probable that U. S. steamer "Yantic" will be in that vicinity; the ice having prevented her progress north, and the harbor at Upernavik not admitting of a long stay at that place. I, with Pike's party, will go hence to Upernavik (his party not being well equipped with boats), keeping as close into shore as possible, but on the outside of the ice. In the event of no ship coming to my relief, I will winter at Upernavik, and divide my party among the neighboring settlements.

Everybody well and in good spirits. With God's help we all hope to reach port in safety in good time.

E. A. GARLINGTON,
1st Lieut., 7th Cav., A. S. O., Commanding.

First whale-boat: E. A. Garlington, 7th Cavalry, U. S. Army; Dr. J. S. Harrison, Acting Assistant Surgeon; Sgt. John Kenney, I Troop, 7th Cavalry; Private J. J. Murphy, F Company, 11th Infantry; Private R. F. Rogge, 3d Infantry; Pvt. F. W. Ellis, Signal Corps Observer; Nicholas, Eskimo, from Godhavn; George Taylor, boatswain of the "Proteus;" F. J. Huostul, Newfoundland.

Second whale-boat: Lieut. J. C. Colwell, U. S. Navy; Corpl. Frank Elwell, 3d Infantry; Artificer O. E. Moritz, 17th Infantry; Pvt. W. H. Lamar, Signal Corps Observer; George A. Wight, A. F. MacDonald, Newfoundland; David, Eskimo, from Disco fjord.

[Copy.]

APPENDIX I.

UNITED STATES RELIEF EXPEDITION,
Cape York, August 12th, 1883.

Lieut. J. C. COLWELL, U. S. Navy.

SIR: Having volunteered for the duty, you will, with your boat and crew as now constituted, except Dr. J. S. Harrison, Acting Assistant Surgeon, U. S. Army, proceed, at the first favorable change in the weather, hence to Godhavn, Disco island, endeavoring to communicate with the U. S. steamer "Yantic," which is supposed to be somewhere along the Greenland coast. When the "Yantic" is found, representation of the present state of affairs will be made to Commander Wildes, and of the proposed route of retreat of the rest of the party by way of Upernavik. In the event of the "Yantic's" having gone south, you will endeavor to make arrangements with any ship which may be at Disco, or neighboring settlements, to come to the relief of my party. The Swedish ship "Sofia," or some of the Danish ships may still be in the vicinity of Godhavn. In case all the ships have gone south, you will make the best arrangements for wintering at Godhavn with your party, taking advantage of the first opportunity to communicate with me at Upernavik, state of your party, and such other information as you deem desirable. You will, however, not send a sledge party for the purpose specially. If no ship comes to our relief, I will winter at Upernavik and divide party among the neighboring settlements. In the equipment of your boat, personal baggage and provisions, you will be governed by your judgment of the necessities of the case.

Wishing you a successful trip, and as pleasant and comfortable one as the conditions will allow,

I am, very respectfully, your obedient servant,

E. A. GARLINGTON,
1st Lieut., 7th Cav., A. S. O., Commanding.

[Copy.]

APPENDIX K.

H. M. S. ENTERPRISE AND INVESTIGATOR,
6th of August, 1848, *Lat.* 75 1-4, *Long.* 59.

Placed in a cairn erected on (the supposed) Browne island. Officers and crews all well, and prospects of a speedy passage satisfactory.

(Signed) JAS. C. ROSS,
Commander of Expedition.

Whoever finds this paper is requested to forward it to the Secretary of the Admiralty, London, with a note of the time and place at which it was found; or, if more convenient, to deliver it for that purpose to the British consul at the nearest port.

APPENDIX L.

WASHINGTON, D. C., *October* 9, 1883.

SIR: In accordance with your request, I beg leave to submit the following report of the movements of the second whale-boat and the party under my command after separating from you at Cape York:

Leaving Cape York on the morning of August 16, we kept together while working

out through the ice until, at 1 p. m., open water was visible to the southward. I then parted company, pulling off to the southward, got into open water shortly after, and set foresail to fresh west-northwest breeze. Steered south-southeast (true) for Upernavik, and about 1.30 p. m. lost sight of all the other boats, under sail, well together, and steering about east. They were in range with Bushman's island, and bore north.

At 2 p. m. I met the edge of another pack, extending to northward and eastward as far as I could see, and kept off to southward to keep inside the broken ice on its western edge. Wind increasing to moderate gale, with frequent snow squalls; close reefed the foresail. About 4 p. m. the south edge of the pack trending off to the northward and eastward, I left the ice and again set course for Upernavik. While inside the edge of the pack the swell was considerable, but the seas did not break. After leaving it I encountered a short, heavy, breaking sea, wind still increasing from west-northwest, until, at 6 p. m., no ice was in sight, with the exception of a few distant, scattered bergs. By that time I was unable to longer steer my course, and was obliged to run before the gale and heavy, breaking sea.

Three of my crew were very sea-sick, and the Eskimo too frightened to understand any English; so I was reduced to two men, and right well they stood to their work. The weather brightened slightly towards midnight, and I saw land to the northward and eastward, but by 1 a. m., August 17, it was again overcast and thick, snow squalls at frequent intervals, wind, however, moderating and hauling to west. At 4 a. m. I gave the tiller to Wight and lay down until 6 a. m., snowing heavily in the meantime, but wind decreasing to light breeze. By burning some alcohol in a tin can I made a pot of tea and warmed some canned meat, the first we had had to eat since starting, with the exception of some wet hardtack.

The wind hauling to southward and eastward, shook reef out of foresail and set mainsail after breakfast, making east course on the wind. Sea still rough and irregular, but not breaking. Sighted land ahead at 9.30 a. m. Wind freshened towards noon and weather looked very threatening to southward and eastward. Close reefed both sails, but was obliged to take in the mainsail soon after. Sea getting up; headed for a small island in sight to northward and eastward, but missed it in a thick snow squall which came up about noon. Sighted it again about 1 p. m., but found myself a mile to the leeward of it with too heavy a sea to attempt to pull against. Ran for a line of icebergs to northward and eastward, to get out of the heavy sea and constantly increasing wind, and at 3 p. m. made fast to a small berg. Snowing heavily, with constantly increasing gale until midnight. I was obliged to cast off my boat and pull to a safer place four times, on account of the berg breaking, or the too close approach of neighboring ones, giving the men a longer pull each time than was really necessary, to prevent their getting benumbed by the cold and wet. I finally made fast to a flat berg with a large mound in its centre, which lasted us six hours, until the gale broke. When I made fast to it it was about one hundred and fifty yards long, but by masses breaking from it, was reduced to barely fifty yards, when I finally left it. While fast to the bergs I kept the bow oarsman with an axe ready to cut the painter in case of sudden danger, but fortunately, we always had timely warning to leave.

During all this time the unfailing courage of the men and their cheerful readiness to comply with any call I made on them, exhausted as they were from loss of sleep, sea-sickness and constant exposure, wet to the skin for two days, and not knowing what minute might be their last, are evidences of a spirit deserving the highest commendation.

The fourteen hours they sat on the thwarts, the oars out ready to pull at a moment's notice, dozing over their oars as they were able, covered with snow, and the boat snowed full, the constant crash sounding in their ears of the hundreds of bergs driven

by before the gale, grinding together and foundering in all directions, and not a despondent word or other than attempts at cheerful remarks from any of them.

About 1 a. m., August 18th, I started a fire with some alcohol in a tin and managed to warm some bacon and a little water for tea, which, with a couple of doses of whisky during the night, prevented their becoming too much exhausted.

At 4.30 a. m. snow stopped, wind moderated, and clouds commenced to break to westward. Saw land to eastward, and recognized the locality as being off Thom island, in Mellville bay, near the place the "Proteus" was stopped on her way north on July 19th. Cleared snow out of the boat, and at 5.30 a. m. started, under oars, pulling to the se.

A few miles to northward of my position the bergs, driven in by the gale, were packed together as solidly as a glacier face, and the view was blocked by them in every direction.

Pulled along through the bergs against a moderate head wind, getting a couple of hours' sleep during the forenoon. About 3 p. m. a light ne. breeze came up, made sail to it and allowed all the crew to sleep. At midnight we were off Cape Seldon, about forty miles distant, and still among many bergs, with occasional strings of lump ice from the bergs.

The men were divided into two watches, the three strongest in one watch, with Corporal Elwell in charge, the other three in my watch. Pulled watch and watch at night, all hands from 8 a. m. to 8 p. m., and this arrangement was kept up until I reached the "Yantic." Saw the sun set below the horizon at 11.30 p. m. on this evening.

Sunday, August 19, shortly after midnight passed a rocky islet one-fourth mile long in n. and s. direction, by one hundred and fifty yards wide, and standing about twenty feet out of water.

Wind increased and hauled to southward shortly after. Could make nothing working to windward, so at 3 a. m. took in sail and tried to pull to eastward, but the wind and sea were too much for the exhausted men. Ran back to the small islet passed at midnight, arriving at 9 a. m. The rock was perpendicular on its leeward side and about twelve feet high. Tied the boat by her painter, keeping her clear with a couple of oars. Started an alcohol fire on the rock and had a meal, the men taking advantage of the opportunity to stretch themselves on the rocks and get a short nap. I found a very old moss-covered cairn in a hollow in the centre of the islet with one very old bone lying near by. Approximate magnetic bearings from this islet: Red Head, ssw.; Cape Seldon, sse. ½ e.; Cape Walker, e. ½ s.; a small islet, nne., about ten miles, and another about ten miles sse., in a line with Cape Seldon. Left a record in a tin can in a small cairn on the summit of this rock, and replenished the water supply from the melted snow in the crevices.

Wind falling light, left at 11.30 a. m. and pulled in for Red Head. Wind dying out, changed course at 3 p. m. to sse. (true.) Made sail at 6 p. m. to light e. breeze, very many bergs and occasional strings of lump ice. Sailed along all night and until 11 a. m., August 20, when, being headed off to sw., took in sail and manned oars, pulling in for Devil's Thumb, which I did not sight until 7.30 p. m. Heavy swell from southward during forenoon and first part of afternoon, until I got in among a great many bergs and lump ice off the coast. At midnight Wilcox Head bore e. (true.)

Pulled along until 1 a. m. August 21, when made sail to light n. breeze, steering sse. Carried sail until 7 a. m., when it again fell calm and oars were manned. Bright, pleasant day. Pulled until 4.30 p. m., when made sail to light nnw. breeze. A heavy fog bank, coming up from northward and westward, shut down thick at 6 p. m. Wind failed at 7. p. m.; manned oars and pulled for passage between Baffin island and main land. Dense fog until 9 p. m., when it lifted sufficiently for me to see the neighboring land and that I was in the channel I was steering for. Calm

and thick fog at intervals until midnight; weather very cold. August 22, commenced clear and cold, fog in patches. Made sail to gentle n. breeze at 2 a. m. At 4 a. m. found we had run in among a lot of high, uncharted islands off a large glacier. Great numbers of bergs and quantities of lump ice, frozen together in solid sheets in places. At 5 a. m. wind died away; manned oars and pulled to southward and westward to get clear of ice. Struck the swell of open water clear of the islands at 9 a. m. Set foresail to fresh nnw. breeze which came up about 9.30 a. m. and steered south. Wind increased to moderate gale; thick fog rolled in from seaward and sea got up. Close reefed foresail, and steered probable course for Upernavik, having concluded to land there to leave notice for the "Yantic," in case she should stop there before I met her.

Not having been able to get a sight of the sun, and fog obscuring the land, I could only estimate my position and supposed I was below Tessuisak at noon.

At 6 p. m. I sighted an island which I supposed to be Long island, adjoining Upernavik island to the sound. Round its south end and hauled up along its east side for next island to northward, looking for the settlement. While sailing along its coast we sighted a barrel on the shore which had a very exhilarating effect on the spirits of all hands, but, on searching the south side of the next island and seeing no signs of natives, they felt pretty low.

The weather had by this time cleared off showing a large glacier to eastward. This, from its size, I took to be Upernavik glacier, that being the only one marked on the chart tracing I had. I informed the men that we had missed Upernavik. and that, after cooking a meal with the barrel we had passed, I did not intend to again land until reaching Godhavn. This decision, to their credit, they very cheerfully accepted, notwithstanding they very much needed a rest and dry clothing,

I sailed back and landed at the barrel, with which I started a fire and cooked a solid meal of the best we had. The place was evidently a summer camp of natives, and had not been long abandoned.

From bearings I got of the glacier, which I supposed to be that of Upernavik (but which afterwards proved to be Tessuisak glacier), and of a high point on the sound, which I took to be Sanderson's Hope, I located myself about eight miles ese. of Upernavik.

Having finished our meal, and after leaving a record in a tin can in a small cairn, we started again at 9.30 p. m. under sail.

August 23 commenced bright and clear, thick to southward and heavy swell. Wind dying away at 1 a m., manned oars and pulled along with the watch. At 2 a. m. I sighted a store house to southeastward, which I supposed to be Proven, and, after a while, concluded to pull in and leave a notice to be sent to Upernavik. Landed at 5 a. m. and sent David to call up the natives at the only hut in sight, not even a dog being visible. He came back with the information that we were at Upernavik, when I roused up the watch in, who had not been awakened by the landing and the shots I had fired to attract attention, manned all oars and pulled around the south side of the island for the settlement on the other side, Danish harbor being the place I had landed. I was met at the landing by Governor Moller, of Proven, with the information that the "Yantic" had left at 9 p. m. the previous evening for the south, a very great disappointment to us all.

The governor of Upernavik, Mr. Elborg, was up and met me when I reached his house, and did everything in his power to make us comfortable. I was given a letter, addressed to yourself, from Commander Wildes, of the "Yantic," in which he stated his intention to fill up with coal at the Kudlisœt mines in Waigatt strait, then to remain at Godhavn not later than September 15th, at which time he would proceed south to Saint John's, Newfoundland.

Wishing to reach him in time to have the "Yantic" come back north for the rest

of the party, who I thought were probably blocked in the ice in Melville bay, I proposed starting at once in my boat. The combined protests of both governors and the minister against crossing Omenak fjord in a whale-boat, a trip that had only once been accomplished, and then at a very great danger, and the urgent offers of Governor Elborg, influenced me to leave my whale-boat and accept a heavy, open launch belonging to him. This boat was also more roomy, admitting of lying down and moving about, impossibilities in the whale-boat. Mr. Elborg wished me to wait two days while he decked it over, but I decided to start the same day, and at 3 p. m. left Upernavik for Kudlisœt mine.

While at Upernavik the hospitality and kindness of Mr. Elborg and Mr. Kristensen, the missionary, could not be exceeded. Everything was placed at my disposal; a large house was assigned the men to sleep in; a substantial meal and all necessaries for their comfort furnished; and all the wet clothing and provisions taken out of the boat and carefully dried. The governor and Mrs. Elborg did all for my personal comfort their kindness could suggest, while the minister presented me with a pair of his own boots, articles of which I stood very much in need, and a chart of the coast, of which I had only a rough tracing.

When we were ready to leave, the entire population, after stowing our supplies in the boat, gathered to see us off, giving us a hearty cheer as we set sail out of the harbor.

On examining my stores at Upernavik, I found nearly all my hard bread sour from having been so long wet, so I had to get a barrel of bread from the supplies of the settlement, the governor of Proven to furnish it from his stores. I was also to get the water casks Mr. Elborg gave me filled at Proven, to avoid longer delay at Upernavik. Mr. Moller, governor of Proven, was to accompany me to that place, and Joseph, an Eskimo from Upernavik, was to accompany me as pilot as far as Svarten Huk, and to lend a hand generally until I returned the boat to Upernavik.

I arrived at Proven at 4 a. m., August 24, sailing to within eight or ten miles of the harbor, when the wind died away and oars were manned. As the boat pulled only four oars and was very heavy, the men found it hard work after the light whale-boat. At Proven I met with the same kindness from Mr. Moller I had experienced at Upernavik. He had the water casks filled for me, furnished the barrel of bread, presented us with two quarters of reindeer, with some fresh provisions and fire wood from his own slender stock, and, when I left at 3 p. m., accompanied me with his boat, towing for two hours. The only return I could make him was the present of my shot-gun and the few cartridges I had remaining.

The weather was calm, so we pulled all night and until 9 p. m. the next day August 25th, when made sail to light n. breeze which lasted four hours. Calm again at 1 a. m., 26th. Manned oars and pulled until 6 a. m., when made sail to light nnw. breeze off Svarten Huk, increasing to moderate breeze and lasting all day until 9 p. m. Manned oars again and pulled until afternoon of the next day. At 8 a. m., 27th, when off Noursoak, about five miles distant, some hyaks came off from shore and, after ascertaining from David who we were, carried the news on shore. Shortly afterwards the governor pulled out to us and again illustrated the hospitality of these people by bringing off some bottles of gin to present us. The governor was a half-breed and spoke very little English, but he informed me he had seen a steamer, presumably the "Yantic," pass down the Waigatt strait on the 23d instant, and that he had news by a native boat that she stopped at Kudlisœt coal mine two days but had left.

Wishing to get word to the "Yantic" as quickly as possible, I wrote a note stating the condition of affairs, and requesting Commander Wildes to communicate with me at Ritenbenk, for which place I would make if I failed to meet him at Kudlisœt. This note the governor agreed to send direct to Godhavn by kyaks, then returned

to the shore. Half an hour later two kyaks passed us going down the strait with the note. Made sail to light nw. airs during afternoon to rest the men, manning oars again at 6 p. m. and pulling till 11 p. m., when I was able to make sail to a gentle nw. breeze, which lasted until 7 a. m. 28th. This was the first night we had had dark enough to necessitate a light to read the compass. Pulled all day and night and until 8 p. m. the next day, 29th. Passed Kudlisœt at 11 p. m. 28, but it was too dark to see more than the "Yantic" was not there. Weather was overcast, heavy fog banks at intervals these two days, and frequent showers afternoon of 29th. Passed settlement of Oyorsasook at 5 p. m., from which two kyaks came off. They said the Noursoak kyaks had passed that day, and that the "Yantic" had passed three days before. I engaged these two men to carry a note to Commander Wildes informing him that I would not stop at Ritenbenk but would keep on to Godhavn.

Made sail to light se. breeze at 8 p. m. and beat to windward until 1 p. m. August 30, making only about ten miles. Manned oars when wind failed and pulled around Fletterhuk (southeast point of Disco island) until 5 p. m., when made sail to light e. breeze.

Breeze increased to stiff wind and hauled to ene., carried all sail before it and ran all night along the coast, about four miles distant.

Ran under lee of promontory on south side of Godhavn harbor at 2.30 a. m., August 31. Double reefed the sails and tried to beat in; wind blowing directly out the entrance. Reef points tore out of the main-sail, and after beating for three hours and making very little to windward, missed stays twice on south side of channel and went on the rocks. I then sent a signal man on the hill to flag the "Yantic," which I could see at anchor in the harbor. I had got the boat clear and was about standing off again when the "Yantic's" first cutter was sighted coming around a point a couple hundred yards away. My boat was taken in tow, and I was brought alongside the "Yantic" at 8.30 a. m.

On reporting to Commander Wildes, I found the note I had sent by kyacks from Noursoak had arrived about an hour previously, and the second note had not yet come.

On my representing the situation of the rest of the party, and their probable condition, Commander Wildes gave orders for getting the ship under way, and at 6.30 p. m. she was steaming out of the harbor for Upernavik, the launch belonging to that place in tow. David, my Eskimo, disappeared when I got alongside the "Yantic" and I did not again see him.

Had pleasant weather, light breezes, and smooth sea to Upernavik, where we arrived at 7.30 a. m., September 2, and I rejoined you with my party.

Very respectfully, &c.,

(Signed) J. C. COLWELL,
Lieut. U. S. Navy.

1st Lieut. E. A. GARLINGTON, 7th U. S. Cav., A. S. O.,
Commanding Greely Relief Expedition, Washington, D. C.

LETTER OF TRANSMITTAL OF CHIEF SIGNAL OFFICER.

SIGNAL OFFICE, WAR DEPARTMENT,
Washington City, October 16, 1883.

Hon. ROBT. T. LINCOLN,
Secretary of War.

SIR: I have the honor to enclose the report of 1st Lieutenant E. A. Garlington, 7th Cavalry, upon the expedition sent to the Arctic seas this summer for the relief of the International Meteorological Expedition, under the command of Lieutenant A. W. Greely, U. S. A. The report describes the passage of the ship "Proteus," carrying stores and a rescuing party for Lieutenant Greely, who with his men were to have been brought away, could they have been reached. The report also describes the loss of the ship and a large proportion of the supplies intended for Lieutenant Greely. The failure to find stores and dogs ready in Greenland, as had been expected, is not understood, since the Danish government had been communicated with upon that subject, at the proper time, which was all that could be done, or had been usual in previous years.

The question of supplementary orders that Mr. Garlington refers to, as having been raised, and in unfairness to himself is, in substance, correctly stated by him. After Lieutenant Greely arrived in Lady Franklin bay, in 1881, he wrote out and sent to this office full directions for the party that might be sent to relieve him, ending as follows: "No deviation from these instructions should be permitted. Latitude of action should not be given to a relieving party, who, on a known coast, are searching for men who know their plans and orders." This made it a matter of greatest delicacy to give any directions that in any manner might change the programme there marked out.

Congress had afterwards, however, added another element to the question, in this, that the party should be brought away this summer. This at first caused the instructions to be determined upon, that the stores be landed at Littleton island before going north of that point. Afterwards it was arranged to send a ship of the U. S. Navy with the "Proteus" as a convoy, and this so far obviated the absolute necessity of first stopping to unload at Littleton island, the convoy itself being a depot, that it was thought best that Lieutenant Greely's directions should remain as Lieutenant Garlington's guide, and that it be suggested only that the landing be first made. Just before starting, Lieutenant Garlington brought a copy of a memorandum that had been prepared for the Secretary of the Navy to aid him in preparing instructions to the convoy, which contained the original condition of first landing at Littleton island, explaining that it would conflict with the plans of Lieutenant Greely, so far as it should consume the time of the expedition, and in case he should find clear weather and open water beyond, with a fair prospect of getting straight through, while by stopping he might lose the opportunity if he should not at once proceed. I replied that the authority and discretion which must always rest with the commander on the spot, must in such case be his guide.

The great delicacy in imposing positive instructions in cases like this seemed to make the simple suggestion in that paper sufficient. The strictures upon Lieutenant Garlington, so far as they refer to the question of disobedience, have been unwarranted.

As to the situation of Lieutenant Greely and his party, while serious, I do not

consider it desperate, and fully look for his rescue next season, preparations for which must be timely and complete. Lieutenant Garlington has been asked to explain more fully, 1st, why he did not endeavor to make a depot at Littleton island, with what stores he could gather during the remaining time he might have remained in that region; 2d, why a large portion of Mr. Greely's stores were abandoned on an ice floe, so long as the season still permitted work with boats; 3d, why, out of six boats, none were left for Mr. Greely and his party; 4th, why he started south with forty days' supply in place of leaving a large portion of them for Lieutenant Greely, when the country was full of game, seals, walrus, and fish, and the party well supplied with means for its capture, which was an ample source of food; 5th, why he came south of Cape York at all, it being in the friendly Eskimo country and fairly supplied with the necessaries of life.

These explanations will be furnished you as soon as received.

I have the honor, sir, to be, very respectfully, your obedient servant,

W. B. HAZEN,

Brig. and Bvt. Maj. Gen'l,

Chief Signal Officer, U. S. A.

REPLY OF LIEUTENANT GARLINGTON TO CHIEF SIGNAL OFFICER.

WASHINGTON, D. C., *October* 20, 1883.

CHIEF SIGNAL OFFICER, U. S. ARMY.

GENERAL: I have the honor to acknowledge the receipt of your letter of the 18th instant, and beg leave to submit in reply to the questions asked the following answers:

1. "Why did you not endeavor to make a depot at Littleton island with what stores you could gather during the remaining time that you might have remained in that region?"

Answer. As I stated in my report, I decided, while at Cape Sabine, to make a prompt and earnest effort to communicate with the "Yantic," and to proceed south at once for that purpose. Having come to this conclusion, I proceeded to gather together all the stores I could spare and reclaim from the bags of the crew of the "Proteus," and make a cache of them on the rocks in Payer harbor under Cape Sabine. The cache made there contained clothing—blouses, trousers, flannel shirts, socks, stockings, mits, buffalo overcoats, fur caps, flannel drawers, undershirts, woolen and rubber blankets; all wrapped in rubber blankets, covered with a tent fly and weighted down with rocks. The supply of clothing is sufficient for twenty-five men for six months. Near this cache is a new top-sail and two boats of new canvas, left by Captain Pike; a sufficient supply to furnish shelter for a large number of men.

In a cove about three miles west of Cape Sabine a cache of provisions was made. This cache contained fifteen sleeping bags, six hundred pounds of hard bread (three barrels and two painted canvas bags), an unknown quantity of bacon, about seven hundred pounds of canned meats, vegetables, and fruits, a box of tea (forty pounds), a box of gunpowder, a can of matches, a tin pot, and a quantity of clothing —all secured as well as possible in a crevice of the rocks, covered with two tent flies, and the whole weighted down with stones. In a conspicuous cairn on the top of Brevoort island, built by the Nares expedition, I deposited a notice of the loss of the "Proteus," a definite description of the locality of the caches of clothing and the provisions, and also of my proposed movements and efforts to communicate with the "Yantic" and return to the relief of Lieutenant Greely.

The record of the late Mr. W. M. Beebe is in the same cairn. I did not disturb the cache left by the expedition of Mr. Beebe of last year further than to see if the stores were in good order and the boat serviceable. The depot of the English expedition on the small island south of Payer harbor was not disturbed.

I brought the members of my party down to one suit of clothing, one change of underclothing, one buffalo overcoat, one sealskin suit, one pair overshoes, two pairs of socks, one pair of mits, and one cap. Everything else was left in the depot. Having made these arrangements, I started for Pandora harbor, stopping at Littleton island to leave a record. In this record I reported the wreck of the "Proteus," my intention to go south and my reasons therefor, and indicated my course along the coast to Cape York. I stated that I would visit Carey islands, but this was afterwards found to be unadvisable on account of stormy weather, the heavily loaded boats, and the inexperienced crew.

The reasons which induced me to decide upon going south at once I gave in my report, but I will enter into them more fully.

After the "Proteus" was lost, I determined to communicate with the "Yantic" as soon as it was possible to do so, to get from her all the supplies that could be spared and establish a depot at Life-boat cove. I intended to remain there with a small party, while the "Yantic" could proceed to Saint John's, report the disaster, and endeavor to secure a vessel suitable for ice navigation and come north with additional supplies. If anything was to be done this season looking to the relief of Lieutenant Greely, it was of the greatest importance to communicate with the "Yantic" at once. When the "Proteus" encountered the pack in Melville bay, no one on board that vessel thought the "Yantic" would cross the bay. This opinion was formed from the known intention of the commander of the "Yantic" not to put his vessel into the ice.

The "Proteus" had run into the "middle pack" about one hundred miles northwest of Upernavik, and it was very nearly four days from that time until she arrived off Cape York. The ice in the bight of Melville bay had not broken this season, and, if the "middle pack" should move off to the westward, leaving a passage around the edge of the fast ice, this ice was still to break up, and would form a pack which would prove a barrier to the "Yantic." As it turned out, to every one's surprise, the "Yantic" saw no ice in Melville bay, and had an unobstructed passage to Littleton island.

If I had remained a fortnight at Littleton island for the chance of the "Yantic's" arrival, my supplies would have been reduced to a dangerously small margin. If she did not arrive, I would have had to commence my retreat during a rapidly closing season, with inadequate provisions. It would probably have been necessary to force our way through much young ice, which at even that date formed one-quarter of an inch thick during calm nights.

This would have delayed the progress of the boats, and prevented communication of the disaster to the "Yantic" in time that she might render any assistance to Lieutenant Greely, if it did not prevent me entirely from reaching the Danish settlements this season, and the sending of the news of the disaster home this year. If I had remained in that region until it was too late to reach the Danish settlements, it would have been necessary to draw on the supplies already deposited for Lieutenant Greely, and if he should arrive he would find his own supplies diminished and the addition to his party of another body of men no better off than his own party. If I started at once, I would secure the arrival of my party at the Danish settlements before the close of the season. If the "Yantic" succeeded in crossing Melville bay, there was nothing to prevent her reaching Littleton island—the "Proteus" having encountered no ice north of Carey islands until she ran into the ice fields of Smith sound, and that ice had not yet moved out to obstruct the channel. I, therefore, reasoned that she would at once, after finding my record on Littleton island, proceed along the coast following my indicated line of retreat, steaming in a day the distance it would take me a week to cover. If she should miss my boats in thick weather, I thought she would endeavor to communicate with me at Cape York, which was my stated objective point. It would then still be early enough to carry out my original plan of remaining at Life-boat cove with supples from the "Yantic," while that vessel proceeded to Saint John's with the news of the wreck.

I left Littleton island on the 26th of July, and on the 7th August had made but one hundred and thirty miles.

I reached Cape York on 10th August, and was confirmed in my belief that the "Yantic" had not crossed Melville bay. The natives at Cape York had not seen any vessel pass to the northward and westward lately, and they knew nothing of the Swedish steamer "Sofia," which was to have come there for a series of scientific observations. This fact convinced me that the "Sofia" had not been able to get

through the Melville bay pack, and if she had not, I thought the "Yantic" most certainly had not.

I afterwards learned that the "Sofia" had reached a point about thirty miles west of Cape York. After starting on the retreat south, I pushed on as rapidly as possible, stopping only when compelled to do so by bad weather or ice. I knew if the "Yantic" did not succeed in crossing Melville bay, it would be necessary for me to make the passage during the month of August. Young ice begins to form during that month, and if it was encountered in extensive sheets it would be fatal to my own party. The few patches of this young ice we had already met cut the bows of my boats badly. The constant exposure and the hard work were already beginning to tell on my men, and it was very questionable whether we would be able to cross the bay. If I had concluded to take the risk of waiting at Littleton island for the "Yantic," I would not have gathered any of the supplies at Cape Sabine and the west coast of Smith sound to form a depot at Littleton island. These stores are much more available to Lieutenant Greely where they are than they could be if on Littleton island. There are three caches of provisions between Lady Franklin bay and Cape Sabine, one of them consisting of two months' supplies for Lieutenant Greely's party. Cape Sabine, according to Lieutenant Greely's own plan, was his first objective point in a retreat south. If he arrives there this season, he will find the record of the loss of the "Proteus," and will know that there is no depot on Littleton island. He will have at Cape Sabine food, clothing, and facilities for making shelter. If he comes south in his boats and reaches Cape Sabine after the 1st September, it is questionable whether he could cross Smith sound at that season, even if he should desire to do so. The ice is then in motion with the winds and tides, and the young ice is rapidly forming. If he should come down later in the fall in sledges (which is improbable), the same difficulties would exist to a greater extent. So, in my opinion, depots of supplies on the west coast of the sound are in better position to afford relief to Lieutenant Greely than they would be if on the other side. I saw no natives about Life-boat cove or Littleton island, nor any recent signs of their presence, so I could not have formed a depot of supplies procured from that quarter. Birds were plentiful, but I had but one shot-gun and eighty-six cartridges in my party, so could not have secured many birds.

Although I made every effort to do so, I was unable to find the guns and ammunition provided for the expedition

Walrus were very numerous, but at that season they were very wild and wary, taking to the water at the slightest alarm; moreover, they sink when shot in the water. A harpoon and line are necessary to secure them. After ice forms of sufficient thickness to bear their weight, they are easily speared or shot if they are caught away from their holes or if the holes freeze over. One of them was shot, but he sank immediately. Seals are difficult to secure for the same reason; several were shot during the retreat, but sank immediately.

In the spring of the year these animals float when killed. Any attempt at securing game would have seriously retarded my progress south, which I desired to hasten as much as possible, for reasons already given.

2d. "Why were a large portion of Mr. Greely's stores abandoned on an ice floe so soon as the season still permitted work with boats?"

Answer. The boats worked all night and until twelve o'clock the next day, getting the stores saved from the ship on Cape Sabine. Each trip was attended with great danger; the ice was all in motion, and running rapidly to the southeast before a strong wind from the northwest and the ebb tide. The large floes of heavy Arctic ice were continually crushing and grinding together, cracks opening and closing, the edges of the floes marked by ridges of ice blocks piled up ten or twelve feet high, by the enormous pressure of the great masses of ice as they jammed against

each other. The boats when pulling through the closing cracks were compelled to haul up on the ice and wait for the crack to reopen. One boat was detained in this way for two hours, being walled in on a circular floe by blocks of ice seven feet thick piled around its circumference. The risk of handling the boats in that sea of moving ice was so great that it was seriously argued by a party of the crew of the "Proteus," then on the floe, to give up the attempt to reach Cape Sabine and trust their fortunes to the solid ice floe they were then on, rather than run the chances of being crushed while endeavoring to make land. When I last saw the floe having the provisions on it, it was about two miles away, the sea between covered with heavy broken running ice, and the floe itself moving to the southward and eastward at the rate of two and a half miles an hour. I lost sight of it soon after, and saw no more of it or any trace of the wreck. The men had now been working almost continuously for twenty-four hours, having eaten nothing except some hard bread and tea during that time, and were worn out with fatigue and loss of sleep. I did not consider the stores remaining on the floe of sufficient importance to again endanger the lives of my men or seriously risk the loss of my boats.

As near as I can ascertain, when the last boat left the floe there remained on it two barrels of assorted canned goods, some loose cans, a small quantity of lumber, two sails, some scattered clothing, the theodolite and some boxes of newspapers.

3d. "Why out of six boats were none left for Mr. Greely and his party?"

Answer. I had two ordinary navy built whale-boats and a dingy. The dingy was a very light, shallow cedar boat, for use in perfectly smooth water and a very light cargo. She would have been of no use to Lieutenant Greely, and I took her along in tow that she might lighten the cargoes of the other boats and serve as a shelter for the men when on land. When I left the shelter of the land at Cape York, she was left above high water mark above that point. The two whale-boats were necessary to carry my own party of fifteen men; one would not have been sufficient. Even with their light crews of seven in one boat and eight in the other their gunwales were not six inches above the water when loaded. They floated lighter at the start, but after a few days, when everything became water-soaked with the frequent rain, snow, and spray, they were dangerously overloaded.

The three boats of the "Proteus" were old, very much out of repair and badly equipped. They had neither spars, sails, nor rudders fitted, and only four oars each could be found for them. Make-shift rudders and sails were fitted at Cape Sabine. I subsequently loaned them one of my sails, which they used in their largest boat throughout the trip. These boats were twenty-one feet, nineteen feet, and fifteen feet six inches long, and carried crews of nine, seven, and six men, respectively. No two of the boats would have carried the crew of the "Proteus." To have left one of the "Proteus'" boats, or to leave one of my whale-boats and distribute my surplus men in the "Proteus'" boats, a resort to force would have been necessary, which I was not prepared to make for the questionable benefit of leaving a boat.

Lieutenant Greely has with him three whale-boats and a steam launch. At Polaris bay, opposite Lady Franklin bay, there is a twenty-foot ice-boat, left there by Lieutenant Beaumont, of the "Discovery;" also a whale-boat in Newman bay, left by the "Polaris."

If he comes to Cape Sabine without boats, there is a whale-boat left there last year and needing only a small patch replaced to be perfectly serviceable. Twenty miles below Cape Sabine, at Cape Isabella, is another whale-boat. He has eight boats available on the west coast and another on Carey islands.

A boat at Littleton island would prove of no benefit to him, for, after reaching the Greenland coast, he would have no further need of boats until next summer, when, it is to be hoped, he will not be reduced to the necessity of trying to make his way south in small boats.

4th. "Why you started south with forty days' supply, in place of leaving a large portion of them for Lieutenant Greely, when the country was full of game, seals, walrus, and fish, and the party well supplied with means for its capture, which was an ample source of food?"

Answer. The exact amount of supplies I had for my party of fifteen men (afterwards increased by one man) when I left Cape Sabine was as follows:

Six hundred pounds of hard bread in bags, a great deal of which got wet and soured and had to be thrown away; three hundred pounds of bacon, eighty pounds of tea; one-half barrel of sugar, one hundred and forty pounds of pemican, from last year's stores, about half of which was spoiled; about four hundred pounds of canned meats, vegetables, and fruits, and one-half barrel of alcohol.

This was a smaller quantity of food than was taken by any party retreating from that region. I could not foretell the exact length of time necessary to make our journey. Dr. Kane retreated from a short distance north of Littleton island to Upernavik, taking with him all the provisions he could carry in his three boats. It took him eighty-four days to make the journey. I made the distance from Littleton island to Upernavik in twenty-nine days.

The "Polaris" people started south with supplies for two months and a half, but were picked up a short distance from Cape York by a whaler, after having been in their boats twenty-three days. At that time of the year I could not expect to meet a whaler, for they only visit the vicinity of Cape York in the early season on their way to the whaling grounds of Pond's inlet and Jones sound, where they remain until September, when they are able to cross Davis' strait, for the southward, homeward bound.

In my answer to your first question I have stated why it would have been impossible for me to have killed sufficient game to subsist my party and at the same time make rapid progress to the southward. I saw no fish in that region, and, if I had, I had no means of catching them. If I had left any of my small stock of provisions at Littleton island, I would have seriously endangered the safety of my men to no purpose. As it was, the short rations of sometimes one, and never more than two meals a day began to tell heavily upon them by the time I reached Upernavik.

After leaving Cape York I saw no game, except two or three seals, until I reached the islands about Tessuisak.

5th. "Why did you come south of Cape York at all, it being in the friendly Eskimo country and fairly supplied with the necessaries of life?"

Answer. I did not remain at Cape York because I did not see then, nor do I see now, how I could have possibly been of any service to Lieutenant Greely.

The friendly Eskimo I saw about Cape York consisted of three families of sixteen people (three men four women and nine children) at one place, and six men at another place about ten miles distant. From these people I learned that the settlement near Cape York, which they indicated as being somewhere to the northward and westward, consisted of about forty people, and that they were only there temporarily hunting, that they would soon return to the main settlement. The only habitations I saw along the coast were several abandoned winter huts, at long distances apart, and the three skin tents in which the three families referred to above were living. From the best information attainable, I am of the opinion that there are no more than one hundred and twenty-five Eskimo from Cape York to Renssalaer bay, and it is a well known fact that they are a very improvident and shiftless race, and on the verge of starvation every winter. To have quartered a party, howsoever small, without provisions on these people with the chance of Lieutenant Greely's reaching there with his party during the fall, would have been but to seriously endanger the lives of the whole community, without being able to accomplish any good whatever. I had not more than two weeks' supplies when I left Cape York, I left that point

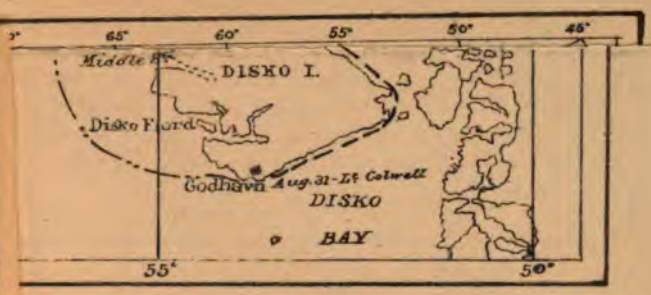
for the same reason I left Cape Sabine—to endeavor to help Lieutenant Greely and party in the only way which seemed to me practicable. As I have stated from the information received there (Cape York), I was convinced that the "Yantic" had not crossed Melville bay, and, consequently, had not found my records. The only alternative left to me was to endeavor to reach Upernavik and Disco just as soon as possible, still making every effort to communicate with the "Yantic," detaching Lieutenant Colwell to make communication more certain.

If my actions in this matter are not explained to the satisfaction of yourself and the honorable Secretary of War, I have the honor to request that a court of inquiry be ordered to investigate the whole case.

Very respectfully, your obedient servant,

(Signed) E. A. GARLINGTON,

1st Lieut., 7th Cav., A. S. O.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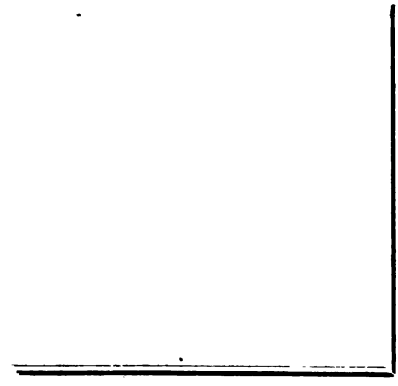

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No. XI.

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THE ELEMENTS OF THE HELIOGRAPH

PREPARED UNDER THE DIRECTION OF

BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,

CHIEF SIGNAL OFFICER OF THE ARMY,

BY

FREDERICK K. WARD,

1ST LIEUT., 1ST U. S. CAVALRY, ACTING SIGNAL OFFICER.

BY AUTHORITY OF THE SECRETARY OF WAR

WASHINGTON CITY:
SIGNAL OFFICE.
1883.

United States — Signal service.

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1883.

1884, Feb. 12.
Gift of
U. S. Signal Service Officer.

FORT MYER, VA., *July* 12, 1883.

To the Executive Officer of the Signal Service, Washington, D. C.

SIR: I have the honor to submit herewith a paper on "The Elements of the Heliograph."

I am, sir, very respectfully, your obedient servant,

F. K. WARD,
1st Lieut., 1st Cav., A. S. O.

THE ELEMENTS OF THE HELIOGRAPH.

A heliograph is an instrument for signalling by sunlight reflected from a plane mirror. The signals are made by flashing reflections, or by obscuring and revealing at will, by a movable screen, an otherwise constant light, which is technically called a "standing flash." The instrument working with a screen has been usually called, by the inventor, a heliostat. That giving flashes has been called a heliograph, or a heliotrope. The word heliograph, however, is commonly used to denote both, and will doubtless continue to be the accepted name. In fact, considering both the derivation of the word and the purpose of the instrument, the name, heliograph, is proper and seemingly preferable.

A complete instrument consists essentially of two plane mirrors and a sighting rod, and, when a "standing flash" is used, a screen. The mirrors are firmly supported, usually on a tripod, and are fitted with vertical and horizontal tangent screws. By means of the tangent screws the mirrors can be turned on their supports so as to face in any desired direction toward the sky. When a movable flash is used, one of the mirrors is so mounted that a motion of three or four degrees about its horizontal axis can be given it independently of the tangent screw, so that the flash can be thrown on and off the receiving station at will, and quickly. The screen, when used, is on a separate support, in order, when working, to avoid any shaking of the mirrors. Both mirrors are used when the signalman facing the receiving station has the sun in his rear. When the sun is in his front, or nearly at his right or left, only one mirror is used. The sighting rod, as its name implies, is an auxiliary used with the tangent screws, to put and keep the mirrors in such a position that the flash can be thrown with certainty on the receiving station.

The principles involved in the heliograph are few and simple: Let S, Fig. 1, represent the sun, and AB a plane mirror. Consider first the light from the sun incident on AB at a single point, c. Only two outside rays are shown in the figure. Since angles of incidence and reflection are always equal, the angle s' is equal to the angle s, and it is apparent, without further explanation, that the converging cone of light from S, incident at c, becomes, after reflection, a diverging cone of precisely the same dimensions. A spectator anywhere within this diverging cone will see the reflected light on looking toward c. The incident cone is a right cone with a circular base; therefore a right section of the reflected cone will be a circle whatever may be the angle of incidence. The radius of the circle will be equal to the natural tangent of $\frac{1}{2}s$, or the natural tangent of the sun's semi-diameter to a radius equal to the distance from c to the plane of the section. This will be apparent from Fig. 2.

Now, suppose AB to be a square mirror, and consider next the four cones of light reflected from the four corners. The angle at the sun subtended by the diameter of the mirror would be inappreciable, therefore the axes of these four cones are sensibly parallel. The cones themselves evidently define the figure of illumination. Pass a plane perpendicular to the axes and they will pierce it in four points, defining a parallelogram, the sides of which will not exceed those of the mirror in length. The axes proceed obliquely from the mirror, therefore the parallelogram will be oblique. Let $DEFG$, Fig. 3, represent the parallelogram. The cutting plane makes a right section of the cone surrounding each axis, and we have already seen that this sec-

tion is a circle having a radius equal to the natural tangent of the sun's semi-diameter to a radius equal to the distance from the cutting plane to the apex of the cone on the mirror. With these radii describe circles about the points D, E, F, and G, and join these circles by tangents. The resulting enclosed figure is a right section of the solid of illumination. Now, since the axes of the four cones are parallel, the dimensions of the parallelogram will be constant for all positions of the cutting plane. The radii of the four circles increase with the distance from the mirror. The mean value of the semi-diameter of the sun is about sixteen minutes, the natural tangent of which to a radius of one mile is twenty-four and one-half feet, very nearly. The mirrors used in heliographs are usually from four to six inches in diameter. Therefore, at a distance of one mile, the circles will overlap and the figure of illumination will be sensibly a circle forty-nine feet in diameter. At a distance of ten miles from the mirror to the cutting plane, or from the sending to the receiving station, the circle of illumination is four hundred and ninety feet in diameter. *And, generally, the diameter of the flash at the receiving station, in feet, is equal to forty-nine multiplied by the distance between the stations in miles.* As the diameter of the flash increases directly with the distance between stations, the adjustment of the instrument is no more difficult for a very distant station than for one comparatively near, provided, of course, that there is some distinguishable landmark to adjust by.

In all patterns of the heliograph yet made the mirror is kept in adjustment by means of what is called the "dark spot." To explain this, let AB, Fig. 4, represent a glass mirror, from which the silvering has been removed from a small circle represented by cd, about the centre of motion of the mirror. The centre of motion must lie in the plane of the silvered surface, and it is usually at the centre of the mirror. Let $f\ c\ f'$ and $g\ d\ g'$ represent the cones of light reflected from c and d, respectively. Between c and d very little light is reflected, and a dark cone represented by $c\ e\ d$ is formed, the angle $c\ e\ d$ being equal to the diameter of the sun. To deduce a general expression for the length of the dark cone, let $c\ e\ d$, Fig. 5, represent the cone, and $m\ e$ its axis, the length of which represent by L. From m draw $m\ n$ perpendicular to the reflecting surface. The angle i is equal to the mean angle of reflection or incidence. Let d represent the diameter of the unsilvered spot $c\ d$, and s the angle $c\ e\ d$, which is equal to the diameter of the sun. Then in the triangle $m\ e\ d$, the angle $m\ e\ d$ being equal to $\frac{1}{2}s$, the angle $e\ m\ d$ being the complement of i, and the side $m\ d$ being $\frac{1}{2}d$, we have

$$L = \frac{\frac{1}{2}d \cdot \cos\ (i - \frac{1}{2}s)}{\sin\ \frac{1}{2}s}.$$

Returning to Fig. 4, it is evident that the axis of the dark cone is parallel to the axes of the cones of reflected light, therefore the direction of the reflected light is indicated by the dark cone. The sighting rod has a small white disc at its upper end. Place the rod so that the centre of the white disc shall be between e and $c\ d$ on the axis of the dark cone as represented in Fig. 6. A dark spot will then be seen on the white disc. Leave the sighting rod in this position. In about one minute the dark spot will have moved to one side of the disc, because of the apparent motion of the sun. It can be returned to the centre of the disc by means of the tangent screws of the mirror. By these means the flash can be held on that distant place which is on the straight line from the centre of the unsilvered spot through the centre of the white disc. Sufficient exactness in this adjustment is not difficult to attain, for, as already shown, the circle of illumination at the receiving station is quite large, and the flash is visible from any point within.

To open communication with a distant station, the mirror being on its support, the sighting rod must be so placed that the centres of the unsilvered spot, of the white disc, and of the receiving station, shall be on the same straight line. This

may be done by looking through the unsilvered spot at the station and placing the white disc to cover it. In practice, however, it is found easier to set the sighting rod by looking into the mirror, so placing the eye that the unsilvered spot exactly covers the reflection of the distant station, and then, without moving the eye or the mirror, bringing the sighting rod into view by reflection and so adjusting it that the reflection of its disc is also covered by the unsilvered spot. Then, if the mirror is turned by its tangent screws so as to throw the reflected sunlight past the sighting rod in such a direction as to show the dark spot on the disc, the flash will be visible from the distant station. If the instrument gives a standing flash, the screen must now be placed so as to hide or cut off the flash except when it is given to view by the operator working the screen. If the instrument gives a movable flash, the mirror must be so turned that the dark spot will appear on the white disc when the key provided to work the mirror is pressed down. When the key is not pressed down, the dark spot will be on the sighting rod a little below the disc, and the flash will not then be visible.

No particular value of the angle of incidence has yet been considered. It is necessary to consider what would be the effect if the light from the sun should fall very obliquely upon the mirror. It has already been shown that the dimensions of the flash are sensibly independent of the angle of incidence. But the case is very different as regards the strength of the flash, and on this the range of the instrument depends. As the obliquity increases, the mirror intercepts less and less light, the reflected flash becomes correspondingly weaker, and the maximum distance from which it can be seen distinctly, that is, the range of the instrument, is decreased; and further, the expression for the length of the dark cone.

$$L = \frac{\frac{1}{2} d \cos\left(i - \frac{s}{2}\right)}{\sin \frac{s}{2}}$$

shows that the length decreases as the angle of incidence increases, becoming practically zero when the angle of incidence is nearly ninety degrees. The dark cone would then fail to reach the sighting disc and there would be no longer any means for keeping the flash on the receiving station. These difficulties are avoided by the use of a second mirror.

Fig. 7 illustrates how the two mirrors are made to serve the purpose. The figure needs no explanation. The mirror which faces the receiving station is usually called the second mirror.

The preliminary adjustment with two mirrors is very similar to that with one. The best method practically is as follows: In setting up the instrument, place the first mirror nearly facing the sun, and the second facing the distant station and a few inches to one side of the line from the first mirror to the sun. Place the eye in front of the first mirror at such a point that the second is seen by reflection in the first, the unsilvered spot of the first covering the reflection of that of the second. A part of the ground in front of the second mirror will be seen in the first by the second reflection. Now, keeping the eye in the position just described, turn the second mirror about its centre of motion so as to bring the distant station into view, or rather so that it shall be exactly covered by the unsilvered spots which still coincide. Then, if the sun occupied the place of the operator's eye, the light would be reflected from the first mirror to the second and thence to the distant station. Next, turn the first mirror by means of its tangent screws so that the dark cone from it shall strike the unsilvered spot of the second mirror. The flash will then be given to the receiving station by two reflections. To make the dark spot visible on the second mirror, its unsilvered spot should be covered by white paper pasted on the back of the mirror,

In the explanation for the single mirror, mention was made of cones of diverging reflected rays only. That there are also converging reflected rays will be evident by supposing the eye placed in front of the mirror and looking into it. There would then be visible an image of the sun (see Fig. 8). This imaginary sun takes the place of a real sun situated back of the first mirror on the straight line through the centres of the two mirrors. The first mirror gives the light to the second from a fixed direction; therefore, after the preliminary adjustment of both mirrors is completed, the second must not be touched. The flash is kept on the distant station by the tangent screws of the first mirror.

With the sun at the zenith the angle of incidence would be about forty-five degrees. Should the angle of incidence with a single mirror approach sixty degrees, the second mirror would be brought into use to decrease it. Sixty degrees then may be assumed as the maximum angle of incidence. The maximum of the sun's semi-diameter is sixteen minutes and eighteen seconds. The diameter of the unsilvered spot is usually about two-tenths of an inch. These values in the equation

$$L = \frac{\frac{1}{2}d, \cos\,(i - \frac{1}{2}s)}{\sin\,\frac{1}{2}s}$$

give ten and six-tenths inches as the length of the dark cone. It follows that when the unsilvered spot is two-tenths of an inch in diameter, the distance from the centre of the mirror to the sighting disc, or from the centre of the first mirror to the centre of the second, must not exceed nine inches, in order that there shall always be a distinct dark spot.

It may be of interest to determine the figure and size of plane mirror requisite to give the maximum strength of flash. Let *AB*, Fig. 8, represent a plane mirror situated a short distance from the eye at *e*, looking at the imaginary image of the sun, formed by reflection. The image will seem to cover a part of the surface of *AB* represented by *m n*. With a very small angle of incidence *m n* will be sensibly a circle from every point of which light is reflected to the eye. That portion of the mirror exterior to *m n* reflects no light to the eye, and therefore adds nothing to the strength of the flash. The diameter of *m n* evidently depends upon the diameter of the sun and the distance from the mirror to the eye. The angle of incidence always has a sensible value, and therefore *m n* would always be an ellipse, of which the shorter axis would be double the natural tangent of the sun's semi-diameter to a radius equal to the distance from the receiving to the sending station. The longer axis would increase with the angle of incidence. From this it appears that, at a distance of, say, ten miles, a mirror four hundred and ninety feet in diameter would be required for the maximum strength of flash. But that would be impracticable, and indeed it would never be desirable, for the flash from a four inch mirror has been seen with the naked eye at a distance of over thirty-five miles, and that from a fifteen inch mirror has been seen with the aid of a small telescope at a distance accurately determined to be one hundred and ninety-two miles.

The mirrors of a heliograph should be of glass. Metallic mirrors would be hard to keep bright in service, and they are open to a still more serious objection. It is necessary that the mirrors be as nearly plane as possible. If of metal they would be liable to become bent or indented. The injury might be so slight as not to be apparent and still be sufficient to make it impossible to give a good flash to the receiving station. Glass mirrors are free from these objections, and experience has shown that those of the small size needed are not likely to be broken. And, too, in the field it would be easier to replace a glass mirror than one of metal.

The heliograph, by reason of its greater range, is a much more valuable instrument for field signalling than the flag. The extreme range of the flag without glasses is not over two miles, and with a telescope having a power of thirty diameters it can-

not be read more than twenty miles. At the latter distance it is only when the atmosphere is exceptionally clear that the flag can be used at all. The average speed in the transmission of messages by flag is about three words per minute, and the labor of swinging is by no means light. A man well practiced in the use of the heliograph can send eight words per minute, and no manual labor is involved. It is more tiresome to receive from the heliograph than from the flag, because the concentration of attention required and the strain upon the eyes are greater. The latter trouble may be much lessened by the use of colored glasses, or better still, of a screen which will cut off the glare of the sky and ground without obstructing any of the light from the distant instrument.

The flash from a field instrument can be seen with the naked eye from thirty-five to fifty miles, and that from a larger instrument having eight or nine inch mirrors, could be seen eighty miles or more without glasses. Permanent stations should be supplied with both sizes. The dust of a command can be distinguished at great distances with glasses. The flash being then thrown on the advance, the command would be almost sure to see it before having moved across and out of it, for at a distance of thirty miles it is nearly one-third of a mile wide. It would most certainly be seen by some one if the whole command was instructed to be generally on the watch for such signals. With each command there should, of course, be a heliograph. By halting a short time the commanding officer might obtain information of the greatest value and at the same time give for transmission to other commands or to headquarters such information as he might possess. In a section where the natural features are favorable, it is easy to see how a few permanent stations could cover a large extent of territory and keep several commands in daily communication with each other, enabling them to operate in concert and to accomplish what would otherwise have been impossible. A very important element of the value of the heliograph in civilized warfare is the fact that, although the station may be in plain view, its signals cannot be seen outside the comparatively narrow limits of the flash. This would be of no value in Indian campaigns, however, for the Indians could not read the signals if they saw them. The location of a permanent station would certainly be known, for enough accidental flashes would be shown in various directions in adjusting, to disclose it. The stations would therefore have to be well protected in an Indian country.

In this paper reference to, or description of, any particular pattern of the heliograph has been purposely avoided. With a thorough knowlege of the principles involved in all of them, any particular instrument can be used without difficulty, although the person may never have seen it before, by first devoting a few moments to an examination of its mechanical details.

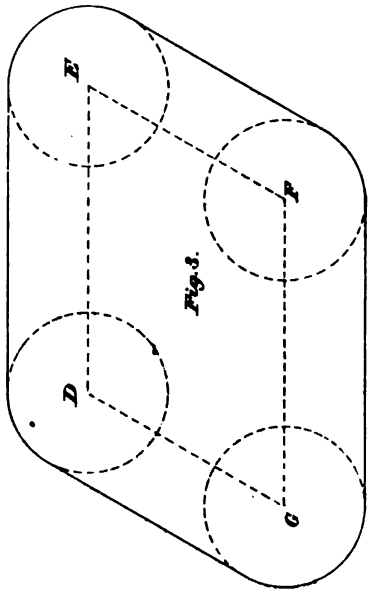


Fig. 3.

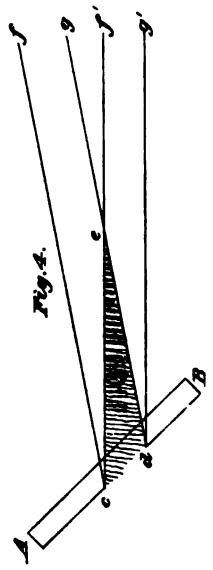


Fig. 4.

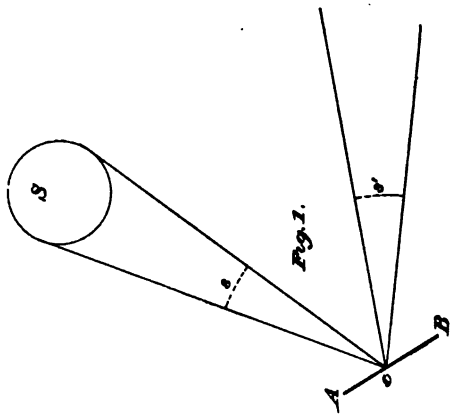


Fig. 1.

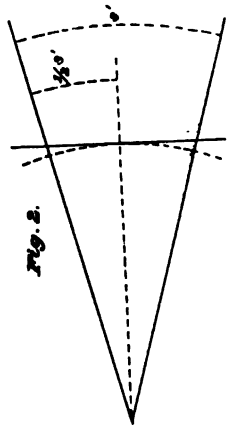


Fig. 2.

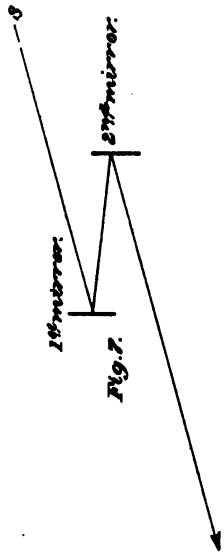


Fig. 7.

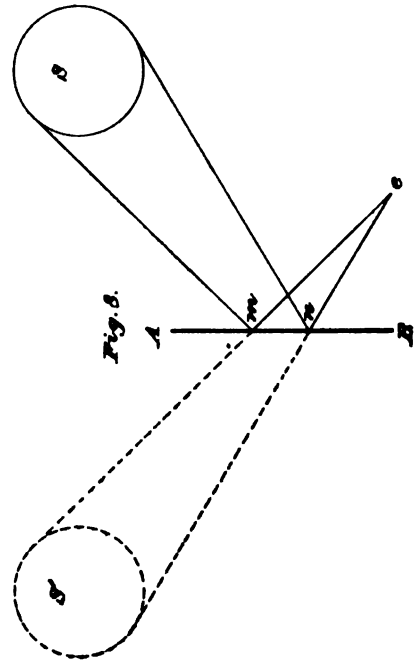


Fig. 8.

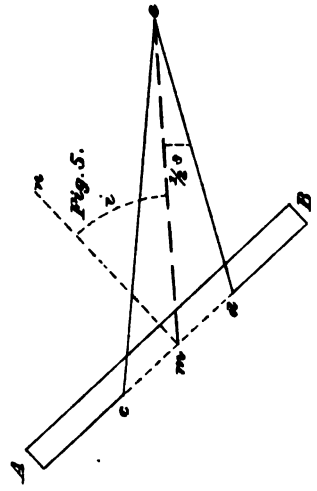


Fig. 5.

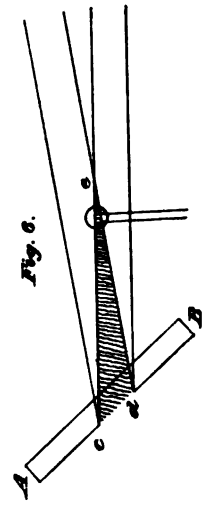
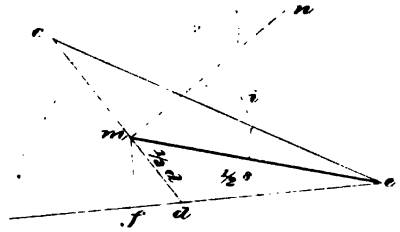


Fig. 6.

The solution of the triangle *med*, Fig. 5, is as follows:



In the above diagram *ed* is produced and *mf* drawn perpendicular to it.

Then Angle $emd = 90^\circ - i$.

Angle $emf = 90^\circ - \frac{1}{2}s$.

Angle $dmf =$ angle $emf -$ angle emd.

Angle $dmf = (90^\circ - \frac{1}{2}s) - (90^\circ - i) = i - \frac{1}{2}s$.

$mf = \frac{1}{2}d$. cos. angle dmf.

$mf = \frac{1}{2}d$. cos. $(i - \frac{1}{2}s)$.

$me = mf \div$ sin. angle med.

$$L = \frac{\frac{1}{2}d.\ \text{cos.}\ (i - \frac{1}{2}s)}{\text{sin.}\ \frac{1}{2}s.}$$

SIGNAL OFFICE, WAR DEPARTMENT.

SIGNAL SERVICE NOTES NO. XII.

THE SPECIAL

CHARACTERISTICS OF TORNADOES.

WITH PRACTICAL DIRECTIONS FOR THE PROTECTION OF LIFE AND PROPERTY.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY.

BY

JOHN P. FINLEY,
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BY AUTHORITY OF THE SECRETARY OF WAR

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THE SPECIAL CHARACTERISTICS OF TORNADOES.

The present pamphlet considers the practical bearing of some of the results of the study of tornadoes, and will answer questions as to the object of this systematic labor under government authority and the possibility of deriving any benefit from the knowledge obtained by scientists.

I.—TERMS.

In the United States, the terms cyclone, tornado, and hurricane, are frequently interchanged in ordinary conversation and, in the minds of nine-tenths of the people, these terms mean one and the same thing. This is not altogether surprising, considering the want of systematic instruction in *accurate* meteorological knowledge, and the general disposition of intelligent minds to speculate about the weather. But, in fact, the tornado of the United States is a well-defined species of storm, differing in many points from hurricanes, cyclones, and thunder-storms, and it is the only one that will now be considered.

II.—TORNADOES.

Omitting consideration of the tornadoes, so called by Portuguese and Spanish navigators on the African coast, and confining our attention to the United States, it is believed that these storms are possessed of the following prominent characteristics: The general direction of movement of the tornado is invariably from a point in the southwest quadrant to a point in the northeast quadrant. The tornado cloud assumes the form of a funnel, the small end drawing near to, or resting upon, the earth. This cloud and the air beneath it revolve about a central vertical axis, with inconceivable rapidity, and always in a direction contrary to the movement of the hands of a watch. The destructive violence of the storm is sometimes confined to a path a few yards in width, as when the small or tail end just touches the earth; while, on the other hand, as the body of the cloud lowers, more of it rests upon the earth, the violence increases, and the path widens to the extreme limit of eighty rods. The tornado, with hardly an exception, occurs in the afternoon, just after the hottest part of the day. The hour of greatest frequency is between 3 and 4 p. m. Tornadoes very rarely, if ever, begin after 6 p. m. A tornado *commencing* about 5 p. m. may *continue* its characteristic violence until nearly 8 p. m., which means, only, that the tornado cloud may be *travelling* after 6 p. m., or after 7 p. m., but it does not *develop*, that is, make its appearance, for the first time after those hours. Outside of the area of destruction, at times even along the immediate edge, the smallest objects often remain undisturbed, although, at a few yards distant, the largest and strongest buildings are crushed to pieces. At any point along the storm's path, where there is opportunity afforded the tornado cloud to display its power, the disposition of the debris presents unmistakable signs of an action of the wind, such as might be called a rotation, from the right through the front to the left around the centre. The destructive power of the wind increases steadily from the circumference of the storm to its centre.

Observations with a single isolated barometer will not indicate the approach of a tornado, however near the position of the instrument to the path of the storm, but

such observations are of value when a number are displayed upon the daily weather map. The tornado season is embraced between the 1st of April and the 1st of September. The months of greatest frequency are June and July. There are, however, instances in a long series of years where tornadoes have been reported in every month of the year. Taking the whole United States together, it is found that the region of greatest average frequency per year, per square mile, embraces the following states: Georgia, Illinois, Indiana, Iowa, Kansas, Missouri, Ohio. The actual figures are about as given in the following table:

Relative frequency of tornadoes, 1874 to 1880, inclusive.

State.	Area in units of 10,000 square miles.	Average number per year for each state.	Average number per year for each 10,000 square miles.
Alabama	6.8	1.5	0.30
Arkansas	5.2	1.0	0.20
Connecticut	0.5	0.2	0.40
Georgia	5.8	3.6	0.62
Illinois	5.5	6.2	1.13
Indiana	3.4	3.0	0.88
Iowa	5.5	3.2	0.58
Kansas	8.1	6.9	0.85
Louisiana	4.1	1.4	0.34
Massachusetts	0.8	0.9	1.12
Michigan	5.6	1.6	0.29
Minnesota	8.4	2.6	0.31
Mississippi	4.7	1.1	0.23
Missouri	6.5	5.0	0.77
Nebraska	7.6	1.8	0.24
New Hampshire	7.9	0.4	0.44
New Jersey	0.8	0.6	0.75
New York	4.7	2.5	0.53
North Carolina	5.1	1.8	0.35
Ohio	4.0	2.6	0.64
Pennsylvania	4.6	1.9	0.46
South Carolina	3.4	1.6	0.47
Tennessee	4.6	1.9	0.41
Wisconsin	1.0	0.2	0.20
Vermont	5.3	1.4	0.26
All of New England	6.8	2.1	0.31

It is not within the province of this memoir to discuss at length the points of difference or harmony, or enter into an intricate analysis of meteorological phenomena and the multiform operations of atmospheric changes attending the origin, development, and complete formation, of tornadoes. On the contrary, it is desired to present a minute consideration of the peculiarities of tornadoes, with a view to placing at the disposal of the people most interested the facts and practical results of past and present investigations of this terrible, yet most interesting, class of storms.

III.—CONDITIONS OF FORMATION.

These may be divided into classes as follows:

First: those within the reach of, and which may be known or investigated by, an isolated observer. To the single observer, located at his farm, workshop, or store, there are important atmospheric conditions which he may carefully watch and study with profit, viz.: the gradual setting in and prolonged movement of the air from the north and south points; the gradual, but continued, *fall* of the thermometer during the prevalence of the former currents, and a *rise* during the predominence of the latter.

If the northerly currents are the prevailing air movements at the place of observation, the atmospheric disturbance is forming southward, but, if the prevailing air currents are from the south, then to the northward of the observer.

Carefully study cloud development, color as well as form; also, manner and direction of approach. Clouds render visible the air currents, and are full of meaning.

A study of the currents of the atmosphere would be impossible without their existence, and that, too, in a variety of forms. Dispense with cloud formation, and the face of the sky would become blank, and severe storms no longer visible.

Wind direction, temperature, and clouds, are proper subjects of observation and investigation by the isolated observer. The barometer is of less importance in this line of inquiry, unless the barometric observations can be promptly compared with those taken at other points near by and at the same moment of time. The tornado itself is an extremely local affair, and the accompanying barometer changes do not affect a large extent of country. Probably if a barometer were placed in the immediate track of the tornado cloud, it would not, with any certainty, indicate the presence of the storm until the crashing winds had fallen upon the instrument.

Second: conditions that can only be witnessed and analyzed by the intelligent eye of the student of the Weather Map.

From this panoramic view of the situation a vast extent of country can be most carefully watched from hour to hour, for days, weeks, or months. Atmospheric conditions on opposite sides of the probable course of the storm can be watched from their inception, and, in any new relations, easily detected and analyzed. From a study of the Weather Map, it has been found that the formation of what is termed a barometric trough or elongated area of low pressure (where the barometer stands below the normal for that region and for the hour of observation) precedes the occurrence of tornadoes in the lower Mississippi valley, or adjoining states to the south and east. This low pressure area assumes the form of an ellipse, and generally extends from southwest to northwest between northern Texas and the upper lake region. Such a depression may lie between the central Mississippi valley and the lower lake region, trending northward just south of Michigan and over the Ohio valley. The longer axis of either of these depressions is easily estimated, while the shorter axis may be stated as generally varying from three to five hundred miles. To the north of the longer axis, even for a distance of several hundred miles, the winds are found to proceed from any or all points between northeast and northwest with comparatively low temperatures, accompanied sometimes by a cold rain or even snow. South of the longer axis, and generally to a greater distance, the winds come from any or all points between southeast and southwest, accompanied by comparatively high temperature, high humidty, and often dashes of quite heavy rain.

As these conditions continue to prevail, the map shows an increasing contrast of temperature on the north and south sides of the longer axis, and as this contrast of temperature gradient increases, the formation of clouds commences in earnest.

An isolated observer in the warm south wind on the south side of the longer axis of course can know nothing of the existence of this cold, dry air to the north of him, but he sees huge masses of clouds of dark and portentous appearance bank up in the northwest and southwest with amazing rapidity, and soon the scene becomes one of awful grandeur.

The upper currents of air are thus indicated by the cloud formations. The condensation of vapor increases rapidly, and huge volumes of air rush upward. The outward indication of the formation of a tornado is first shown in the whirling, dashing clouds over the broken surface of the heavy bank of condensed vapor forming the background; a scene not easily depicted or realized by one who has not witnessed it, but never to be effaced from the memory of the actual observer. The next stage in the further development of this atmospheric disturbance is the gradual descent of

the funnel-shaped cloud. The tornado is now before us, not fully developed, but soon to acquire that condition.

IV.—PREMONITORY SIGNS.

On the day of the storm, and for several hours previous to the appearance of the tornado cloud, what indications of its probable formation and approach are within the comprehension of an ordinary observer and can readily be detected by him? A sultry, oppressive condition of the atmosphere, described by various observers as follows: "I really experienced a sickly sensation under the influence of the sun's rays." "I was compelled to stop work on account of the peculiar exhaustion experienced from physical exertion." "It seemed as if the lightest garments that I could put on were a burden to me." "There was not a breath of air stirring." "The air, at times, came in puffs, as from a heated furnace." "I felt a want of breath, the air frequently appearing too rarified to breathe freely." "I was startled at the sudden and continued rise in the thermometer, especially at this season of the year." "It was terribly oppressive; it seemed as if the atmosphere was unusually heavy and pressing down on me with a great weight."

Enough examples have now been cited to indicate the effects and signs of this oppressive sultriness. Other signs may be found in the development and peculiar formation of the clouds in the western horizon. Sometimes these peculiar clouds extend from the southwest through the west by the north to the northeast. More frequently, however; they form in the northwest and southwest, sometimes commencing, first in the former quarter and then again in the latter, but in either case they are equally significant. The marked peculiarity of the clouds is found to occur not only in the *form* but in the *color* and *character* of development.

The sudden appearance of ominous clouds, first in the southwest and then almost immediately in the northwest or northeast (or perhaps reversed in the order of their appearance), generally attracts the attention of the most casual observer. In almost all cases these premonitory clouds are unlike any ordinary formation. If they are light their appearance resembles smoke issuing from a burning building or straw stack, rolling upward in fantastic shapes to great heights; sometimes they are like a fine mist, or quite white like fog or steam. Some persons describe these light clouds as at times apparently iridescent or glowing, as if a pale whitish light issued from their irregular surfaces. If the premonitory clouds are dark and present a deep greenish hue, this fairly forbodes very great evil. So, also, if they appear jet black from the centre to circumference, or if this deep set color appears only at the centre, gradually diminishing in intensity as the outer edges of the cloud or bank of clouds are approached. Sometimes these dark clouds, instead of appearing in solid and heavy masses, roll up lightly but still intensely black, like the smoke from an engine or locomotive burning soft coal. They have been described as of a purple or bluish tinge, or at times possessed of a strange lividness, or frequently dark green, and again of an inky blackness that fairly startles you with its intensity.

The following are extracts from reports of observers: "They were the worst looking clouds I ever saw; perfectly awful." "The clouds seemed to be boiling up like muddy water, the upper surface of the cloud reminding me of the incessant eddies or whirls seen in the muddiest portions of the Missouri river." "I saw two whirling circles of lightish gray clouds in the west; they were acting independent of each other, and moved slowly inward toward each other from opposite directions. The clouds were very low; seemed to be on the earth, the wind in contrary directions across the face of the western sky, and surrounding clouds in great confusion." "Observed clouds moving in all directions; some of a dark green color, others white as steam." "The lower end of the cloud was very white, like fog." "I saw

a great smoke, and supposed, at first, it was a fire." "I saw a terrible cloud, of a dark purplish color." "There was a peculiar and terrifying look to the clouds." "I saw a green cloud in the northwest, surrounded by others not so deep set in color. Under the cloud from the southwest, there came a large number of little thunder-heads, some very dark, but others as white as steam. They seemed to be separated and running very low. I never saw clouds so low before. Pretty soon they began to go in all directions, some up, some down, right and left, backwards and forwards. I next saw a cloud that looked even all over in color and very white, the edges being pretty regular. It moved remarkably steady, and seemed to be right under the edge of the cloud from the southwest." "I noticed a strange action in the clouds, and saw a cloud rolling on the ground coming from the southwest." "The ground was covered with white, steamy looking clouds, that prevented one from seeing any distance." "Two clouds, one from the northwest, and the other from the southwest, seemed to meet, and, after meeting, passed still lower. Above their place of meeting, black smoke appeared in very peculiar shape." "The air presented a very peculiar appearance; it seemed to be in different shaded strata and quite marked." "At the bottom of the cloud a hazy appearance rose up, obstructing the view," "Two clouds came together; one from the southwest and the other from the northwest; the latter was the higher, and the former the heavier and looked the worse." "A heavy cloud spread out before us to a width of about six hundred feet, and as black as night."

The peculiarities of the clouds while they are forming is another interesting and significant feature which should be carefully watched. Under ordinary circumstances, clouds form, move, and disappear, without exciting special remark or, perhaps, thought, from the casual or even the interested observer. In the event of a thunder-storm or hail-storm, the movement and disposition of the clouds are not looked upon with fear or as possibly possessed of a power to create great havoc, but on the occasion of a tornado the formation and movement of the clouds strike most persons dumb with fear. There seems to be some strange connection between the almost simultaneous appearance of clouds in the southwest and northwest, possessing, as they do, such unusually threatening forms. As they approach from opposite directions, they are suddenly thrown into the greatest confusion, breaking up, as it were, into small portions, which dash pell-mell over each other and in every direction, now darting toward the earth, now rushing upward to considerable heights or at moderate elevations, rolling over each other in a well developed whirl. An observer, in describing the approach of the clouds from the southwest and northwest, stated that they "came together with a terrific crash, as if thrown from the mouths of cannons." Generally, following closely upon the existence of this condition, the funnel-shaped tornado cloud appears against the western sky, moving boldly to the front from without this confused mass of flying clouds. As the tornado cloud advances, these clouds continue to play about its top and sides, constituting a characteristic feature of the scene.

Another and invariable sign of the tornado's approach is a heavy roaring, which augments in intensity as the tornado cloud advances. This roaring is compared to the passage of a heavily loaded freight train moving over a bridge or through a deep pass or tunnel, or as heard on damp mornings when the sound is very clear and loud. At times the roaring has been so violent that persons have compared it to the simultaneous "rush of 10,000 trains of cars." Again, the roaring is likened to the low rumbling of distant thunder. The varying intensity of the roar, as here represented, is apparently due to the lack of uniformity in the positions of the various observers with respect to the advancing tornado cloud. Those situated nearest the cloud, other things being equal, experience the loudest roar, while to those at greater distances the noise is proportionally weaker. In any event, however, the

noise is sufficiently peculiar and distinct to create alarm, and as a means of *warning* should not be overlooked under any pretext.

V.—CHARACTER OF TORNADO CLOUD AND ATTENDING MOTIONS.

The tornado cloud is, generally speaking, at its first formation, funnel-shaped, that is to say, it tapers from the top downward, not always in the same degree with every appearance of the cloud, but the lower end of it (the part nearest the earth) is invariably the smallest, and this, too, whatever may be the inclination of the central axis of the cloud to the vertical or plumb line. As seen in different positions and stages of development by various observers, located differently, the tornado cloud has been called "balloon-shaped;" "basket-shaped;" "egg-shaped;" trailing on the ground like the tail of an enormous kite;" "of bulbous form;" "like an elephant's trunk;" &c., &c. In the majority of instances, however, observers describe the cloud as appearing like an upright funnel. When the small end of the cloud just reaches to the earth, the violence of its whirl causes a peculiarly formed cloud of dust, and finely divided debris, around which play small gatherings of condensed vapor. To all appearances now, the tornado cloud has two heads, one on the surface of the earth and the other in the sky, the bodies of each joining in mid-air and tapering both ways with the smallest diameter at their junction. In other words, the cloud now assumes the shape of an hour-glass, and the lower portion displays extraordinary destructive violence. This last and most fatal form of the tornado cloud is fortunately not a constant feature of the storm. The tornado cloud is constantly changing from the hour-glass form to that of the upright funnel, or some other intermediate shape previously referred to.

The various gradations of form, not any of which, however, affect the stereotyped relation between the size of top and bottom, number some twenty-five or thirty, so far as reliable information has been secured upon this point. These variations of form depend upon the peculiar movements of the whirling currents of air within and about the tornado cloud, the direction of the currents being outlined to the eye by the singular disposition of the rapidly condensing masses of vapor. The characteristic motions of the tornado cloud number four, and are described as follows:

No. 1. is called the *whirling* or *gyratory* motion of the tornado, which is invariably from the right by the front around to the left. This whirling motion, in all probability, exists in the air preceding the formation of the tornado cloud, and should, therefore, be placed first in order of consideration. Its velocity is far in excess of any of the others. Many efforts have been made, but most of them altogether fruitless, to estimate this velocity, and results, ranging from 100 to 800 and even 1,000 miles per hour, have been deduced, but no great precision can be assigned to such figures. In the majority of instances the determinations have ranged between 100 and 500 miles per hour. Theoretical velocities of over 2,000 miles per hour, based upon certain assumed atmospheric conditions, have been deduced. Such velocities are mathematically possible but not meteorologically probable.

The uncertainty of the computed velocities results largely from the difficulty attending the acquirement of absolutely reliable data. In all carefully conducted investigations heretofore made, such a long time has intervened between the occurrence of the storm and the arrival of the person authorized to commence the work, that valuable and satisfactory results in this direction are precluded. It is always of prime importance to ascertain definitely what portion of a building or other object was first struck by the wind and what the configuration and inclination of the exposed surface. As a rule such determination has been rendered next to impossible by the rapidity with which devasted districts recover from the violence of the storm. This statement is a most praiseworthy and well deserved commentary

on the exemplary industry and determined spirit of the people, especially of the lower Missouri valley.

With the gyratory motion of the tornado cloud objects are drawn inward to the centre of the storm, and then carried violently upward by a spirally inward and upward motion which fairly crushes and grinds into pieces buildings, trees, and whatever else stands in the line of the advancing cloud. The spirally upward motion throws the ascending debris in a circular manner outward at the top of the tornado cloud. This debris, when beyond the central whirl of the cloud, falls to the earth, but in such a manner and so disposed as to indicate the character of the force which acted upon it.

No. II. is called the *progressive* motion of the tornado cloud taken as a whole, or the motion which determines the cloud's progress from one point to another. The rate of progressive velocity ranks next in order to the velocity of motion No. I., although it is certainly at all times far below the high degree of the latter.

The rate of progress of the tornado cloud is subject to great variability throughout the duration of any one storm. Some observers have indicated the movement by the following expressions: "All in an instant." "Gone in a moment." "Quicker than thought." "Without a moment's warning." "It moved no faster than a horse gently galloping." "I just saw what it was, and then it was all over." "Before I had time to turn about in my tracks it flashed by me." "It seemed to remain almost motionless, as if held to the ground by some mysterious force." "I shuddered, held my breath, and the monster had vanished." "It seemed to move no faster than I could run."

These estimations of velocity are not to be taken literally. The circumstances under which the impressions were received must be considered, viz.: undue excitement, or abject terror. However, the comparative results are important, and, to a certain extent, reliable. In view of them, people will at least not underestimate the awful grandeur of the panorama, or fall into the fatal mistake of encouraging a belief that the tornado is not what the united experience of all observers has portrayed it.

Such data will not answer, however, to figure on very closely, but the items, average diameter of cloud, actual time (local or standard), and measured distances, are greatly desired as a basis for accurate study. Reliable data are very difficult to obtain, especially of time. This fact should be thoroughly appreciated by observers, and every reasonable effort made by them to examine their clocks or watches upon the approach and passage of a tornado cloud. Generally speaking, it is a good habit to form, of jotting down, in some place of ready reference, the hour, day, month, and year, of notable events.

In regard to this matter of time, so far as past determinations can be valued, the progressive velocity of the tornado cloud, taken as a whole, is variously estimated at from twenty-five to seventy-five miles per hour. The former is perhaps too low and the latter quite likely too high, and, although in both instances they represent the extremes, yet either of the above velocities may have existed for short intervals. The general average is probably about forty miles per hour.

No. III. is termed the *rising* and *falling* motion of the tornado cloud, the character of which finds definition in the following expressions from various witnesses: "The top of the cloud seemed to pop up and down, and then to rush forward." "It bounded over the ground like a ball." "It was the strangest jumping and flopping object I ever saw." "At times it seemed to lash the earth in terrific fury with its huge tail." "It came along, popping up and down in a most fantastic way." "Rising up like the uncoiling of a huge rope, it cut loose from the earth and passed over us with a horrible whizzing sound." "Ever and anon it would shoot directly upward from the earth, sometimes with great rapidity, and then again quite slowly, each time dashing to the surface with renewed vigor."

It is, perhaps, clearly seen that this is a distinct motion, with striking peculiarities which define its character. Sometimes, upon the lifting of the tornado cloud from the earth, it does not again descend for a distance of several miles, at times making the return movement or descension twenty or thirty miles distant, the intervening space proving a complete blank in its track. More frequently, however, these gaps are from one to five miles in length.

While the tornado cloud is traversing the atmosphere at some considerable distance from the earth, it may reach down so low as to just skim over the tops of the highest trees; descend to a level with the roofs of buildings, simply scaling off the shingles in spots or entirely on one side, leaving the roof-boards and rafters unmoved; removing the tops of chimneys; taking out all the fans in the wheels of a windmill and leaving every portion (even the tail) of the remainder of the mill unharmed; taking off the cornice without disturbing the remainder of the roof; removing simply the top boards, or one or two of the top rails, of a fence.

The tornado cloud may, however, remain at a perfectly safe distance throughout its aerial course and where it may be seen at a great height, moving solitary and alone, like a huge balloon. While in this condition it has, not a few times, been unwittingly taken for the latter object, but the mystery and sensation were entirely dispelled when the news came in from the surrounding country of the frightful power of this now silent monster.

There is still another feature of motion No. III.: upon rising from the earth and passing through a few uncertain struggles, apparently to decide upon the final direction of movement, the tornado cloud is ultimately lost sight of in the surrounding clouds, but reappears suddenly at some point, either to descend or to remain above at a safe distance.

No IV. is called the *zigzag* motion, or swaying of the tornado cloud from side to side of a general line of progress. This motion is sometimes quite suddenly performed, but generally it is a moderately slow movement, and one that can be watched and easily identified. It seems to occur most frequently just as the tornado cloud touches the earth, as described in the preceding motion No. III., when the cloud will often diverge about an equal distance on either side of the central line of movement.

At the commencement of this motion, the tornado cloud always moves first to the left (N. N. W.) and then to the right (E. S. E.). On the return movement, the cloud may or may not cross the major axis to the right (E. S. E.). The zigzag movement from one side to the other of the central line of progressive action may continue for several miles, or it may be cut short after the first few moves.

The regularity of this peculiar action appears to be in connection with indraughts of violent currents of air from the south side of the major axis, which frequently advance (only from the left side) and give evidence of their existence by swaths or narrow paths of destruction (alternating with spaces of no damage) cut inward toward and joining with the central line or track. The tornado cloud may, upon the return movement, whether executed upon the north or south side of the major axis, fail to cross it, but upon reaching it continue onward in the central line of movement to the northeast.

The distance travelled by the tornado cloud in departing from the major axis, either to the right or left, is subject to considerable variability, ranging from forty or fifty yards to nearly as many rods. While executing this zigzag motion it very frequently happens that the tornado cloud simply skims over the earth, without manifesting its extreme violence.

VI.—ELECTRICITY.

The rain and hail which sometimes precede, and at other times follow, the tornado cloud, but always accompany the heavy clouds which form in the north and

west, is generally, but not always, attended by lightning; sometimes by most violent manifestations and then again by occasional flashes. The most terrific displays are reported during the heavy precipitation which often occurs ten or twenty minutes after the tornado cloud has passed. Very often flashes are observed in the dark clouds which begin to rise above the western horizon an hour or more before the storm.

What relation has electricity to the formation and power of the tornado clouds? Most persons are utterly at a loss to account for the prodigious power manifested in the destructive effects of the tornado. If they make the least attempt to philosophize upon the subject, they are determined to assign the cause to some mysterious interference of electrical force. Whenever a piece of iron is bent, broken, twisted, or carried a considerable distance, a tree torn up by the roots, or clothing snatched from the body, it is attributed to electricity. The fact that lightning does not appear in the tornado cloud itself is explained away by supposing some incomprehensible modification of its usual character. There is a dogmatic predisposition to attribute everything unusual to this one member of the category of physical forces. Of course it is the easiest way to get rid of a difficult problem.

Even if electricity is present, there is no requirement of its intervention to produce the force required. It is plainly evident that the movement of a current of air at the rate of two hundred to five hundred miles per hour is sufficiently powerful to demolish the strongest buildings, lift a piece of iron or, if necessary, distort its shape.

VII.—PROTECTION OF LIFE.

How can people save their lives or avoid terrible injuries? In regard to this, much, if not everything, depends upon the manner and direction a person *moves*, together with the distance of the tornado cloud, its direction, and the kind of *motion* prevailing at the *instant* one determines upon changing his position.

We will now suppose the various conditions, and proceed to point out the necessary action in each instance. In all cases it is granted, for the sake of convenience in illustration, that you are in front, or situated directly in the line, of the advancing tornado cloud. Under these circumstances, if *progressive* motion No. II. of the cloud is prevailing and your distance from it, say, eighty rods (one-fourth mile) or more, *move* directly, and with all possible dispatch, to the *north*. Whenever this motion is prevailing, *always* run to the *north*, unless in so doing you would be obliged to cross the *entire* path of the storm. A sharp glance to the *westward* will tell you whether you are about on the *southern* edge of the probable *path* of the tornado cloud, or more to the *north*. If in the *centre* or *half way* between the *centre* and the *southern* edge, your chances are best in a direct course to the *north*. If further to the *south*, move directly and very rapidly to the *south*, bearing slightly *east*. In *no event* should you ever run directly to the *east* or *northeast*. Suppose the tornado cloud to be distant from you (W. or SW.) eighty rods (one-fourth mile) and its progressive velocity sixty miles per hour, it would advance one mile in sixty seconds, or eighty rods in fifteen seconds. Assuming the average width of the destructive path of the tornado cloud to be forty rods and your position at the centre of that path, it will be seen that you have fifteen seconds in which to reach the outer edge of the path to the *north* (a distance of twenty rods) before the tornado cloud could arrive at your location.

An extreme case has been assumed in every particular. Most persons first see the tornado cloud at a much greater distance, from one to three miles, sometimes five and even ten miles on the prairies. Of course at the unusual distance of five or ten miles you could not determine very satisfactorily its probable course, especially with regard to your buildings or the safety of your own location. Watching the approach

of the tornado cloud closely at a distance of ten miles, and from that position on and on in its eastward course until it came within a mile or so of your point of observation, would give you sufficient opportunity to predict its probable course in regard to your location. When that matter is settled satisfactorily to your judgment, *move* immediately and without further hesitation. If you wait until the tornado cloud is distant one mile, you have at least sixty seconds in which to run a distance of thirty rods, supposing that you are obliged to cover more than half of the destructive path of the storm. In an average case you will probably have between eighty and ninety seconds in which to run a distance of twenty rods. In either case it is assumed that you are prepared in every particular to *move* at the very *instant* of timely warning. Further, it is assumed that you have been watching the weather of the day and understand that a terrible storm is imminent. There is, under ordinary circumstances, no reason why you should not be so informed. A tornado cloud does not come out of a clear sky, and there are many and ample signs of its approach.

What has been said in regard to the *directions* in which persons should move when the progressive motion is prevailing will, for all practical purposes, apply to motions Nos. I. and III. With respect to motion No. IV. (the *zigzag*), the following preliminary remarks should be most carefully considered: While possessed of this motion the tornado cloud crosses from one side of the central line of movement to the other. This peculiar motion most frequently occurs just after the termination of the *rising* and *falling* motion (No. III.), so that when you see the tornado cloud descending to the earth from one of its aerial flights, you may expect the *zigzag* motion to follow. The first departure of the tornado cloud from the general path of the storm's progress is to the left or on the *north* side of the path; all departures from the general direction, whether left or right movements of the tornado cloud, are invariably executed to the *eastward*. There is no backward movement to the *west;* in the event of any departure it ultimately returns to the central line of movement. Having these points well in mind, you are prepared to act when the exigency occurs. When the departure of the tornado cloud is to the *left* and your position is at any point near the central path, *move* directly *north* with the utmost rapidity, even if the cloud is at a long distance from you. Should it chance that your distance from the cloud is reduced to twenty or forty rods, run instantly to the *south*, bearing slowly *west*. This movement will take you away from the forward and return action of the tornado cloud. Another case: Suppose your position to be the same as just given, viz.: near any point in the central line of movement, but with the tornado cloud just crossing over the line to the *south*. In this event you should move instantly and directly to the *north*, bearing slowly *west*. This movement will also, as in the case previously cited, take you away from the forward and return action of the tornado cloud.

To recapitulate in regard to tornado cloud motions and the manner of movement with respect to them: never wait until the tornado cloud is almost upon you before you move, and, remember, under no circumstances, move to the *northeast*, *east*, or *southeast*.

Many foolhardy acts have been committed (perhaps through fear and excitement or positive ignorance) by persons, which have resulted in death or terrible injuries, because they tried to run in front of the tornado cloud, thinking they could outstrip it in such a race. Others have attempted to cross the path just ahead of the advancing cloud, feeling that they could reach a safe distance on the opposite side before the funnel-shaped monster passed. In one of our late storms a person assayed this trip with two horses and a lumber wagon, confident that he could at least rush his horses across the apparently narrow path of storm which seemed to progress within such circumscribed limits; he was instantly killed, one of his horses dreadfully mangled, the other seriously injured, and the wagon a total wreck.

VIII.—PROTECTION OF PROPERTY.

What can be done to lessen, in any way, the actual damage (present or prospective) to property, especially buildings? Since it is utterly impossible to move them from the path of the advancing tornado cloud, and quite as impossible to construct any buildings strong enough to completely resist the extraordinary violence of the tornado cloud, it is equivalent to saying that you can never expect to save your buildings, a conclusion to which all thought upon the subject will, sooner or later, conform. It is advisable that, under all circumstances, you should avoid any labor *especially directed* to the construction of any buildings whatsoever, for the express purpose of resisting the violence of the tornado cloud. Build your houses, barns, and stores as you would without the *knowledge* of a tornado. Other things being equal, a *frame* building is better than a *brick* or *stone* one. The former will hold together longer, is more elastic (if you will permit the term), and persons seeking refuge within its walls are much less liable to injury. There has occasionally been evidence to show, that of all frame buildings, those constructed with a hip roof and a story and a half in height, were the best able to resist the violence of the tornado; but where there are cases reported of this class of buildings being saved, there are as many, if not more, where they were destroyed precisely as any other frame building would have been under similar circumstances.

It matters not how you construct, or of what material, if your building rises above the surface of the earth (which it must necessarily do), it thereby offers obstruction to the advance of the tornado cloud, and it will go, either from the foundation, or into kindling-wood and a distracted mass of bricks and mortar, in spite of the propagation of any theory or the possibilities of architectural skill. The narrow belt of destruction renders it practicable for a whole state, through insurance companies, to bear the loss that occurs at any one point. Cheap buildings and general insurance is the wisest policy.

IX.—BUILDING SITES.

In regard to the matter of buildings, the question may be asked whether there is not some choice in a building spot, with a view to safety from the violence of the tornado. Many persons have thought that if their house or barn were perched upon some high "divide" or on the brow of a steep decline, in fact upon any marked rise above the surrounding level, the tornado cloud would rise from the earth and pass over it. But observation seems to show that the tornado cloud pursues a general course to the northeast, without regard to the character of the earth's surface, and if buildings are in the line of its destructive path, whether upon a hill, in a valley, or within a ravine, they are liable to be subject to its violence. Western towns, as a rule, are not built upon high "divides," but more frequently sheltered between neighboring hills. The same may be said of farm buildings; it being the prevailing custom to select building spots along the low bottoms of streams, for convenience to water and timber, and for protection from the continued heavy winds that break over the open prairies. Repeated investigations have shown that buildings were destroyed with as great violence and completeness upon high lands as upon low lands, but the larger number in valleys, because of the facts above cited. In many instances the funnel cloud has passed from one ridge to another, doing damage on both, but skipping the intervening depressions; again it has followed high "divides" for several miles when they coincided with its general course of movement. Ridges and valleys are almost invariably crossed at right angles when their courses are from northwest to southeast.

X.—DUG-OUTS.

Since we cannot resist the power of the tornado, the question now suggests itself, what precautionary measures can be taken? That which remains to be done can be accomplished in an unostentatious, and quiet, but secure, manner. Every man can and should construct a "dug-out" at some suitable point, within a convenient distance of his house. If a person is situated within a town or city, let him select some portion of his yard for the purpose; but if residing in the country, he will not be confined to narrow limits in the selection of a desirable location. Where a person living in a village has no yard, he must, if he has a cellar, construct a cellar-cave, as a means of protection, to be described further on. With respect to the "dug-out," in no event should the roof be other than level with the surface of the earth; in fact, it is highly desirable that the retreat should be so constructed that the ordinary surface of the earth would form the roof or covering, and that all preparation of the domicile proceed by way of excavation and supports from beneath. As to location, there is not much to be said; the most important points being: convenient distance, a high, dry place, and possible opportunities to excavate into the northern or eastern slope of a knoll or hill. In the latter instance, the entrance way would suffer less from the violence of the storm, providing, perhaps, that it did not entirely envelop your retreat, for, in that event, in the whirl of the flying debris, all sides alike would be at the mercy of the winds. Having decided upon the location, as regards your house or other buildings, prepare to sink a shaft, say four to six feet square, the entire depth of your "dug-out." From either the northern or eastern (better the former) wall of this shaft, cut out a stairway leading upward to the surface of the earth, for purposes of ingress and egress. On the side of the shaft opposite the stairway, commence the excavation for the enclosed retreat. The size of the room will, of course, depend upon how much you may at any time wish to secure from injury. Better have the excavation too large than not large enough. The slight difference in the expense of time and labor may, perhaps, be the means of saving you a great deal when you least expect it. The entire room should be below the surface of the ground a distance of at least three feet, and the overhanging roof of earth should be supported from beneath by heavy timbers, to provide against any emergency, like the dashing of heavy debris or the tramping of horses and cattle upon it.

In the event of a tornado, your retreat ("dug-out") may be entirely buried beneath huge piles of debris, therefore everything must be made as secure as possible. The entrance door should be made of the heaviest timbers and supported between casings of similar strength of construction. Arrangement should be made to secure the door by heavy fastenings. In order that ventilation may be provided for, two box spouts, squaring eight inches, should be let through the roof. The top of these spouts must be level with the surface of the ground and protected by iron gratings. Ventilation may also be provided for by openings through the upper portion of the door, and these also should be protected by iron gratings.

The "dug-out" should be large enough to contain your family and such personal effects as are considered most valuable. There are many instances where persons have lost very valuable articles, even large sums of money, from supposing that if such things were placed in securely bound trunks or boxes they would be perfectly safe. There are cases where iron-bound trunks and even iron chests (not the regular merchant's safe) especially made to secure valuable articles, have been crushed or torn to pieces and the contents scattered to the winds. A heavy safe might resist the force of the wind to the extent that it would not be broken open, but it may cost you several hundred dollars, and even then you must prepare a "dug-out" for your family. Why not expend this money, or that portion of it which is found necessary,

in preparing not only a secure refuge for your family but also sufficient room for your valuables? This "dug-out" need not prove a worthless investment, even though you do not experience a tornado. On the principle alone that "an ounce of prevention is worth a pound of cure," the outlay cannot be considered a failure. It may be used for various purposes as an out-door cellar. If it proves the means of saving a life but once in five years (your own among the number), you would hardly regret the expenditure.

There is still another kind of underground protection which can be prepared to advantage, if you are provided with a cellar, either under your house or store. Having the cellar, cut an opening (say six feet high and four feet wide) into the *west* wall. Carry the excavation to such an extent underground as to provide sufficient room for your family and valuable personal effects. The roof of this cellar-cave should be composed of at least three feet (in depth) of the undisturbed surface earth, and supported from beneath by heavy timbers. In every way it should be made as secure as the "dug-out." The provisions for ventilation may be made through the roof or entrance door, but in either case well protected by iron gratings.

XI.—PROTECTION IN CASES OF EMERGENCY.

In case you are possessed of a building that has no dug-out or cellar-cave, your best plan is to *move* from your house, or from the location where you are at the *instant* stationed, as directed in the previous sections. If not able to benefit by these directions, retreat instantly to your cellar and place yourself, face forward, against the *west* wall. This is the best position in any cellar. If, for any reason, you cannot get to the *west wall*, take your position (the next best), face forward, against the *south* wall, but as near the *southwest* corner as possible. In case the building is removed from the foundation, it will always be carried above and over you, or, if torn to pieces, the debris will be instantly removed to the eastward. *Under no circumstances, whether in a building or a cellar, take a position in a northeast room, in a northeast corner, in an east room, or against an east wall.* Remember that the tornado cloud invariably moves in a *northeasterly direction*. Persons have been instantly killed, or terribly crippled, for no other reason than that they ignorantly threw themselves in the very grasp of the monster cloud.

The rule regarding the movement to the *northeast* must be obeyed. The *northeast* quarter is a fatal position, whatever may be said about destruction to life or property in any other. If, unfortunately, you are close pressed by the advancing cloud, never remain *standing* and attempt to weather the storm, but throw yourself *prone* (face downward) upon the ground, head to the east, and arms over the head, to protect it. If you should chance to be near a large stone or stump, or some heavy, low object firmly imbedded in the ground, take a position directly to the east of it, lying prone upon the ground, head toward the object, protecting the former with your folded arms. This advice is given in the event of extreme necessity, where other and better opportunities are unavailable or have been forfeited. It is better, if possible, never to trust yourself behind or about any movable object located within the centre of the storm's path; by all means not a tree or anything that rises some distance above the surface of the ground. If you can get out, never remain in a house, or any other building that is at all likely to be torn down or removed from its foundation. If forced to remain in a building without a cellar, always take a position against the *west* or *south* wall (better the former), either prone (face downward) upon the floor or standing with your back to the wall.

In any building, always take your final position on the first or ground floor or in the cellar. Never stand or lie in front of a door or window, or near a stove or heavy piece of furniture. Make every effort to get into the *west* room and, if possible, before the onslaught, remove all furniture from the western portion. If you

have the necessary time, shut tightly every window and door in the building within which you may be located at the time of the storm.

Never take refuge in a forest, in a small grove of trees, in an orchard, in a building, or near a fence of any kind, unless such obstruction is entirely out of the line of the storm.

If possible, always open the doors of your out-buildings and let your stock loose, driving them to the north, as before directed; or, if the tornado cloud seems about to pass to the north of your buildings, your stock should be driven *southward*, the rules being, of course, the same as for human beings.

XII.—PROTECTION IN TOWNS AND CITIES.

With regard to the protection of life and property in towns and cities liable to be visited by tornadoes, what has already been suggested in the matter of *north* and *south* movements, "dug-outs," and cellar-caves, will, of course, apply here. But where a large number of persons are congregated, each intent upon his particular business, some provision should be made for the mass of inhabitants who are performing their various duties in and out of doors, and who, by reason of their peculiar situation or labor, cannot, if they would, stop to study the prognostics of the sky.

With regard to this matter a few suggestions will be offered which may not be amiss. On any day when the weather conditions presage the probable approach of a violent wind storm, it should be the duty of those in authority to deputize certain persons, one or more in each ward, the number depending upon the size of the town, to watch the character of the sky and approach of the storm, and, if a tornado, to give timely warning of its advance to the various families in their respective wards, and take charge of the removal of persons and property to places of safety. In the matter of warning the various portions of the town, it would probably be to advantage to make use of the church and school bells, by ringing them, in some peculiar manner, to be decided upon by previous arrangement and generally understood. It should be well known that the persons above referred to are possessed of special authority while performing their duties. They should be cool, brave, active, intelligent, and judicious men. They should completely understand the situation, know precisely what is needed and how to supply it. All men should appreciate the situation of these persons, and avoid confusion, by a strict compliance with orders. It will not be necessary for these persons so deputized to be adepts in the science of meteorology, or to devote their time, from the 1st of April until the 1st of September, exclusively to observations of the sky.

The signs (as before described) of tornado cloud formation and approach are distinct and sufficiently suggestive to afford opportunity for timely and concerted action. The time for action will necessarily be limited, and the watch need not commence until there is every reason to believe that such a course is absolutely necessary. No one should smile at the novelty and minuteness of this arrangement, or at the idea of employing weather guards at western towns. It is a means of precaution very competent for the protection of life and property.

XIII.—STATE WEATHER SERVICES.

The State Weather services of Ohio, Indiana, Kansas, Nebraska, Missouri, Iowa, and other states, under the efficient supervision of their several directors, are doing most excellent general meteorological work. They should receive the hearty aid and appreciation of the people and of the legislatures of their respective states. Every state should have a weather service, every township an observer, and every chief observer at the county seat be authorized to receive monthly reports from the various observers within his jurisdiction and forward the same, monthly, to the state

director of such service. Each director should have the time and force at his disposal to thoroughly digest the meteorological conditions of each and every month, throughout the year, preparing and publishing, at the termination of each month, and also at the close of each year, a general summary of atmospheric phenomena coupled with the evidence of earnest and well directed efforts toward comparative study and practical results.

Such funds as are necessary to carry forward a work of this kind should yearly be appropriated by the state legislature. As so organized, and when in working order, each state weather service should co-operate with the United States Weather Service, at Washington, and thus complete a system of meteorological work which would effect a marvelous advance in the study of this most important science.

There is no country on the face of the globe where meteorology can be studied with so much advantage, practically and scientifically, as in North America. The elementary principles of meteorology, especially in regard to storms, should be taught in every high school. In the colleges and universities an advanced course should be prescribed. Wild speculations regarding the laws of the weather are exceedingly rife, touching every branch of the science, and, in view of this, *facts* and *principles* should alone be considered in conducting the prescribed course of any educational institution.

It is not believed that in this concise presentation of important facts the results altogether meet the supreme desire, or, perhaps, the hope, of the people interested in the subject of tornadoes. Such desires or hopes may never be realized, not, at least, until the investigation and analysis of these phenomena have been perfected; yet you have before you in very brief form the results of over five years of labor and an examination of over 600 tornadoes.

XIV.—THE OBSERVATION AND RECORD OF TORNADOES.

In order to be prepared for the possible appearance of a tornado, so far, at least, as local indications are concerned, let every person situated in those regions of country where the tornado is of yearly occurrence commence to carefully observe and record the daily changes in the face of the sky, the variations of temperature, the direction of the wind, and the character and development of clouds. Not that any person should devote most or all of his time to this work of observation, nor even all of his spare time, but, for the sake of regularity and uniformity, certain hours for regular work of this nature are advised, viz: 3, 7, and 11 a. m., 3, 7, and 11 p. m., Washington time.

Should unusually interesting phenomena occur during the period between these hours of observation, it would be advisable to increase the number of observations, making these at as short intervals as the importance of the case demands. By means of these frequent observations, every feature of the storm becomes the subject of inquiry and quite probably more important results attained. For purposes of investigation of tornadoes the observations need not continue throughout the entire year, at least in the northern and western states, although such a length of record would be of great value for other purposes; but observations should certainly begin by the 1st of April and continue, unremittingly, until at least the 1st of September. Observations through the autumn can be maintained with profit.

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SIGNAL SERVICE NOTES NO. XIII.

Met. 8.

THE RELATION BETWEEN

NORTHERS AND MAGNETIC DISTURBANCES

AT HAVANA, CUBA.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY,

BY

G. E. CURTIS,
SERGEANT, SIGNAL CORPS, U. S. ARMY.

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NOTE.

The publication of this paper as a Signal Service Note is for the purpose of bringing it to the attention of the public; the endorsement, by the Chief Signal Officer, of the views set forth is not to be inferred therefrom.

ON THE RELATION BETWEEN NORTHERS AND MAGNETIC DISTURBANCES AT HAVANA, CUBA.

The data for an extended comparison of simultaneous magnetic and meteorological changes were first furnished by the observations of the Göttingen Association, taken from 1834 to 1841. In the discussion of these observations, Sir Edward Sabine presented the following as the result of such a comparison: "No connection or correspondence whatsoever was discovered between the indications of the magnetical and meteorological instruments, nor had the state of the weather any perceptible influence. It happened very frequently that an extremely quiescent state of the needle was preserved during the most violent atmospheric storm, and as with wind storms, so also thunderstorms, even when close at hand, exercised no perceptible influence on the magnetic instruments." How well this conclusion has been sustained by the comparison of subsequent magnetic and meteorological records made at different European observatories, may be seen from the following quotation from a recent paper by Balfour Stewart (see British Association Report, 1882):

"As a matter of fact, all attempts to trace a likeness between simultaneous magnetical and meteorological phenomena have been without success."

This lack of any well-defined correspondence with meteorological changes, together with their observed simultaneity at widely distant stations, has resulted in hypothetically assigning the causes of terrestrial magnetic perturbations almost entirely to solar or cosmical changes. Among others, in an address before the British Association, Prof. W. G. Adams, after a comparison of the magnetic records of distant stations, says: "It is clear that the cause or causes of magnetic disturbances are, in general, far distant from the earth's surface." Exceptions to this concurrent testimony are, however, not wanting.

One of the earliest and one of the most important of the attempts to connect magnetic disturbances with atmospheric changes was made by Father Secchi, who maintained: first, that the magnitude of the diurnal variation of the magnetic needle bears a definite relation to the direction of the wind, being greater for south winds than for north winds; and second, that magnetic disturbances occur at Rome with "bourrasques," or, as we call them, northers. Secchi's methods were severely criticized by J. Allan Broun, who claimed: first, that the supposed effect of the wind arose from the fact that the wind from a given direction was in predominance at times of increased magnetic activity; and second, a study of the observations at Singapore and Makerstown, during times of northers, failed to present the slightest evidence of a result like that of Secchi's.

More recently Father Benito Viñes, S. J., director of the magnetic and meteorological observatory at Havana, has re-affirmed the conclusion of Secchi. In his volume of Havana observations for 1873, he states that the cold northers at that place are accompanied by magnetic disturbances and suggests, as the cause of this relation, that the different electrical conditions of the warm and moist equatorial current and the dry cold air of the norther, produce differences of magnetic potential which are manifested by disturbances in the magnetic instruments. This conclusion, differing so widely from that of many other European meteorologists and

magneticians, would seem to deserve thorough investigation. The meteorological conditions at Havana are furthermore, in respect to the cold north winds termed northers, somewhat different from those of stations in western Europe, and the statement of a coincidence between *them* and *magnetic* changes is worthy of an independent investigation. It is the object of the present paper, by a careful examination of the Havana observations with the aid of additional information, obtained by the study of the tri-daily Weather Map and Monthly Weather Review of the United States Signal Service, to determine the nature of the connection, if any, existing between the northers and magnetic disturbances, and the weight of evidence supporting the hypothesis of Viñes. Only two years and a half of the Havana observations, namely, from July, 1872 to January, 1875, are available for the purpose of this investigation, as the observations since 1874 have not been published, but we have the same data for reviewing the hypothesis that Viñes had for maintaining it. The reports of the observatory, for the above-named years, contain all the magnetic and meteorological observations projected in monthly curves; while in the accompanying text the atmospheric conditions attending the principal magnetic perturbations are briefly reviewed. The magnetic outfit of the observatory consists of a declinometer and a bifilar magnetometer. No description of the construction, location, or environments of these instruments, a knowledge of which is so important in the discussion of magnetic observations, is contained in the reports. The only information obtained is that derived from the internal evidence of the observations themselves.

That the instruments are protected from mechanical vibration and consequent disturbance in the record during the prevalence of violent wind storms, seems to be assured by the fact that during many such storms the magnetic curves present only the regular diurnal changes. The question whether the instruments are subject to sudden and large changes of temperature, and, if so, the possibility of perturbations being occasioned, either by a change in the magnetism of the magnet bars, which the assumed temperature corrections do not entirely eliminate, or mechanically, by currents of air produced, can not be satisfactorily settled without a record of the temperatnres of the room. Finally, the question of the uncorrected errors produced in the motions of the needle by the effect of torsion, developed in the suspension threads during large changes of temperature and humidity, should receive especial examination in any discussion of the disturbances occurring at such times. But, as far as can be ascertained, no such investigation was instituted by Viñes, and his conclusions are consequently subject to the uncertainties which arise from the fact that all the sources of instrumental error may not have been eliminated.

In the subsequent discussion, however, we must proceed on the supposition that such mechanical disturbances do not take place, and that all the perturbations recorded in the observations and displayed in the curves are due to true magnetic changes. An inspection of the Havana magnetic curves shows the bifilar to be much more sensitive to disturbance than the declinometer. Many violent disturbances take place in the bifilar of which there is but little or no trace in the declinometer, while a disturbance in the declinometer rarely occurs without a concomitant variation in the bifilar. The condition of the bifilar has, therefore, been taken as the criterion of a magnetic disturbance. In general, days on which the range of the bifilar is greater than fourteen scale division, or fifteen and six tenths (15.6) minutes of arc, have been considered as days of disturbance. In a few instances in which the daily range during the month was found to be very small, ranges of only twelve or thirteen scale divisions, being relatively large, have been classed as disturbances. Upon this basis a tabulation of all disturbances has been made (see Table I.) in which the size of each is indicated by the range in scale divisions. Those months are omitted from the table in which the subsequent investigation

showed that no northers occurred, and which were consequently not pertinent to the discussion. The table contains also a list of the more prominent auroras occurring in the United States and Canada during the same period. Some of these, obtained from American journals, are quoted in the Havana observations, and the remainder are selected from the most extensive and brilliant of those recorded in the Monthly Weather Review and Chronological list of Auroras (Professional Paper No. III. of the United States Signal Service).

TABLE I.—*Showing range of the bifilar magnetometer in scale divisions on days of disturbance, together with a list of auroras.*

	1872.						1873.													
	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May.		Sept.		Oct.	
	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.
1			17	a					20	A	22	a	25	A						
2	17	a		a					13	A			17							
3	18		20		15	a	18				20		14		14			a		
4			14	a					28	a	19									
5	17	A	23				35	A			24	a								
6	17		21		14	a	17						19		17	a				
7			15				60	A									17			
8	15			a			16		17		37		14	a		a				
9			15	a	28	A*			23		36	a	14						20	
10			53	A							16	a								
11			27				18													
12	28						15		14											
13															16		19	A		
14	69	A			19												13			
15	19		14	}							17				20	A				
16	26	}		}							19									
17		}			22		16													
18	18	}	16				33	A					24	A						
19							24		17				17	A	16		15	A		
20									17	A			16	A	14	a	18	a		
21									15	A	26	A		a					19	a
22					16					a	29	A			16	a				a
23			24	a	18	a			13	A		a								
24				a			27		17	a	15	a						A		
25							23				15									
26		a	14				17	a							19					
27												a								
28	18	A													20	A				
29	14	A			18									a			16	A		
30													19	A				A		
31					14	a														

* Aurora in Europe.

A indicates auroras brilliant or extensive.

a indicates extent or brilliancy not reported.

} indicates that the range of the bifilar occupies two days.

TABLE I.—*Showing range of the bifilar magnetometer, &c.*—Continued.

	1873.				1874.															
	Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May.		Oct.		Nov.		Dec.	
	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.	Range of bifilar.	Auroras.
1	26										32									
2																				
3											21		16 }		63	A			13	A
4					14		56						15		28	A				
5					12		17						15 }		15	a	15			
6											13	A	15 }		18	a	13			
7									36	A	24	A								
8																	15			
9			15								14									
10							15						14							
11																				
12		a†													18	a }	19			
13	21	a†							22 }		18					a }				
14			17	A												a				
15			15		27	A							15			a				a
16					15	A									18					
17					24	A	13								14					
18									17											
19	13				13				13											
20							14										14			
21																			27	a
22																				
23																	28			
24					12															
25	28								14											
26			17										22		13 }		14			
27					35															
28									16		14						13			
29	15																			
30																				
31			16 }																	

Auroras faint.—Monthly Weather Review.

Auroras faint.

No extensive auroras.

† Auroras in England.

A indicates auroras brilliant or extensive.

a indicates extent or brilliancy not reported.

} indicates that the range of the bifilar occupies two days.

For better study I have designated by a capital letter those auroras which are known from the above or other sources to have been brilliant or extensive, and by a small letter, those whose size and brightness was, in general, not recorded; the inference does not therefore necessarily follow that they were small or faint.

Of thirty-eight auroras marked *A*, thirty-six are coincident with magnetic disturbances, and of forty-three auroras marked *a*, twenty-seven are accompanied by disturbances. The significance of these auroras in the discussion will receive attention hereafter.

Having obtained, as in Table I., a list of the magnetic disturbances, the occurrence of northers was the next subject of examination. The characteristics of a norther as given by Viñes, are as follows:

For several days preceding there is a south wind, with maximum temperature and minimum pressure, At the moment of declaring itself the norther consists of a direct turn of the wind through the west to the north, rapid fall in temperature, tension of vapor and relative humidity, with rapid rise of the barometer. The norther is considered to continue as long as these conditions are presented. In many cases where the conditions of a norther at Havana, as above given, were only partly realized or were present in very small degree, the tri-daily Weather Maps and Monthly Weather Review of the United States Signal Service, were consulted for additional information concerning the atmospheric changes over a large area of country.

Independently of the comparison by Viñes, the relation of each norther to the oc-

currence or non-occurrence of magnetic disturbances was separately studied, and the characteristics of each case noted. The result of this examination is embodied in Table II. and list of northers. In Table II. the atmospheric conditions, on dates of magnetic disturbances, are presented in detail; when these indicate the existence of a norther the fact is noted in the last column of the table. Having found, as in Table II., the number of northers accompanied by magnetic disturbances, a list was then made (see page 10) of those northers during which the magnetic curves present only normal oscillations with no evidence of disturbing influences, and also of a few cases when the motion of the needle, though not normal, was not considered as disturbed by the foregoing classification.

TABLE II.—*Meteorological conditions on days of magnetic disturbance.*

Date.	Pressure.	Temperature.	Wind.	Remarks.
1872.				
October 2	Normal	Low and irregular.	North, very light	Not a norther.
October 3	Normal	Rapid afternoon descent.	Northeast and east	
October 5–6	Falling	Normal	East and northeast.	
October 7–8	Low	Normal	North	
October 12	Normal	Normal	North	
October 14 to 18	Rising till the 17th.	Restriction in daily range, but no large descent.	14th, north preceded by turn through the west; velocity high; 16th to 18th, east.	A norther on the 14th and 15th. Violent magnetic disturbance in Europe.
October 28	Normal	Very heavy fall.	North since 24th	
November 1	Normal	Normal	East	
November 3	Normal	Normal	East	
November 4	Normal	Normal	East	
November 5	Normal	Normal	East	
November 6	Normal	Normal	East	
November 7	Normal	Normal	East	
November 10–11	Rising	Falling	Variable and light.	
November 15–16	Rapid rise	Large fall	North, high velocity.	Perturbation very small; a steady rise in the curve of the Lifilar from the 15th to the 23d, when a straight and rapid descent takes place; a norther begins on the 16th and continues to the 23d.
November 18	Falling	Very low; no diurnal range.	North, continues from 15th to the 23d.	
November 23–24	High and falling.	Regains its normal.	North with change to east; end of the eight days north wind.	
November 26	Normal	Normal	Variable and light.	
December 3	Normal	Normal	Northeast	
December 6	Normal	Normal	East	
December 9	Rising slightly	Restriction in range.	North, but light	
December 14	Falling	Normal	East	
December 17	Normal	Normal	East	
December 21–22	Rising	Falling	North, turn by the west, good velocity.	A norther.
December 23	Falling	Normal	East	
December 29	Normal	Low	North	Not a norther.
December 31	Falling	Normal	East, velocity high.	Disturbance small.
1873.				
January 3	Normal	Normal	North	
January 5	Rising	Falling	North, velocity high.	A norther.
January 6	Normal	Irregular	North, preceded by turn through the west.	
January 7–8	Normal	Falling	North, continues from 6th to 11th.	Conditions of a norther begin on the 6th and extend to the 11th.
January 11–12	Falling	Low	Northeast and east, high velocity.	
January 17	Rising	Falling	North, turn by the west.	A norther.

TABLE II.—*Meteorological conditions on days of magnetic disturbance.*—Continued.

Date.	Pressure.	Temperature.	Wind.	Remarks.
1873.				
January 18–19	Rising	Falling	North continues	
January 24–25	Rising	Falling	North	Fall in tension and humidity; a norther.
February 1	Rising	Restriction in range.	North	Coincident with norther beginning January 31st.
February 4	Normal	Normal	Northeast and east	
February 8–9	Rising	Falling	North	A violent norther.
February 19	Normal	Normal	Variable	
February 20	Falling	Normal	Variable	
February 21	Stationary	Normal	Variable	
February 23 24	Rising	Restriction in daily range.	North	A norther.
March 1	Normal	Normal	South	
March 3	Rising	Falling	North	A norther begins on the 3d.
March 4	Rising	Falling	North	
March 5	Rising	Rising	North	
March 8	Falling	Normal	East	
March 9	Falling	Normal	East	
March 10	Normal	Rising	Northeast	
March 15	Normal	Rising	East	
March 16	Normal	Rising	East	
March 21–22	Rising	Restricted range.	North, turn by the west.	A norther.
March 24–25	Normal	Normal	South	
April 1	Normal	Maximum high followed by sudden fall.	East and southeast	
April 2	Normal	Normal	North and east	Not a norther.
April 3	Rapid rise after p. m. minimum.	Normal	North and east	Not a norther.
April 6	Diurnal range large.	Normal	East	
April 8	Normal	Normal	East	
April 9	Steady rise	Irregular fall	East	
April 18	Normal	Low and irregular.	North	Fall in tension and humidity.
April 19	Rise	Low and irregular.	North	A norther begins on the 17th.
April 20	Large range	Normal	North	
April 30	Rapid rise after p. m. minimum.	Normal	North and east	
May 3	Normal	Maximum, with sudden fall, on 2d; small range on 3d.	North, preceded by south and turn through the west; velocity light.	A norther of small intensity.
May 6	Very low p. m. minimum.	Normal	East and northeast.	Not a norther.
May 13	Very low p. m. minimum.	Range small	East and northeast.	
May 15	Normal	Range large	South	
May 19	Normal	Irregular	East	
May 20	Normal	Irregular	Southeast	
May 22	Normal	Normal	Northeast	
May 26	Normal	Irregular	Northeast	
May 28	Irregular	Irregular	Northeast and east	
September 13	Normal	Normal	Variable	
September 29	Falling	Normal	Northeast	Seven other small perturbations during the month.
October 9	Normal	Normal	Northeast, preceded by east.	Not a norther.
October 21	Ascent beginning on the 19th.	Descent beginning on the 19th.	North and northwest from the 17th to 22d.	Condition of a norther, but beginning some days before; on the 19th a rapid but small oscillation begins in the bifilar with a steady upward tendency in the curve, continuing until the 21st, when a straight and rapid descent takes place.
November 1	Rising	Nearly normal	East	
November 13	Rapid rise	Rapid descent	North, preceded by west.	A norther.
November 19	Large rise	Rapid descent	North, preceded by west.	A norther.
November 25	Normal	Normal	Variable	

TABLE II.—*Meteorological conditions on days of magnetic disturbance.*—Continued.

Date.	Pressure.	Temperature.	Wind.	Remarks.
1873.				
November 29	High, the rise occurring on the 28th.	Low, the fall occurring on the 28th.	North, beginning on the 28th.	Norther begins on the 28th; a rise in the curve of the bifilar begins on the 28th and continues till the 29th, followed by a straight descent.
December 9	Normal	Irregular	Northeast	Not a norther.
December 14	Normal	Low	North, northeast, and east; high velocity.	A norther.
December 15		Almost normal.		
December 26	Rising	Heavy fall	North, preceded by west; high velocity.	A violent norther; the magnetic disturbance is very small.
December 28	Continued ascent.	Descent.	North, preceded by west.	Norther; perturbation is quite small.
December 30–31	Stationary	Low	North	
1874.				
January 4–5	Normal	Normal	Variable	
January 15	Falling	Minimum	North	
January 16	Falling	Normal	East and south	
January 17–19	Rising	Normal	South and west	
January 24	Rising	Normal	Northeast	
January 27	Falling	Normal	East	
February 4	Normal	Diurnal range.	North	
February 5	Normal	Restricted.	East	
February 10	High	Large descent.	North	A norther.
February 17	Normal	Normal	East and north	
February 20	Normal	Normal	East	
March 7	Normal	Normal	North and east, velocity small.	Violent perturbations.
March 12–13	Rising	Descent	North.	Descent in tension and humidity; a norther.
				Four other days of disturbance in March, but accompanied by no especial meteorological changes.
April 1	Slight rise	Normal	Variable	
April 2	Slight rise	Range restricted.	Variable	
April 3	Slight rise	Range restricted.	Northeast	
April 6	Falling	Normal	East and north	
April 7	Falling	Normal		
April 9	Normal, followed by rise on the 10th.	Normal; fall on the 10th.	South, turn to north on the 10th.	
April 13	Ascent	Normal	Violent northeast.	
April 28	Descent	Normal	North	
May 3	Normal	Stationary.	Variable	
May 4	Falling	High maximum	Variable	
May 5	Stationary	Low	West and northwest.	Descent in tension and humidity; norther begins on the 5th.
				Three additional perturbations in May, with no marked atmospheric changes.
May 6	Rising	Low	Northwest	
September 7	High	Descent	Mostly east	
September 11	Normal	Normal	Variable	
September 12	Rising	Low	Southeast	
September 29	Rising rapidly.	Normal during perturbation, falling immediately after.	Southwest, light, change to north after perturbation.	
October 12–13	Nearly stationary.	Descent	Northeast	Seven other days of disturbance not accompanied by marked atmospheric changes.
November 5–6	Normal	Normal	Northeast	
November 8	Normal	Normal	East, strong	
November 12	Normal	Normal	Northeast	
November 20	Normal	Descent after perturbation.	North, very light	
November 23	Falling	Normal	East and north	
November 26	Rise	Fall	North	A norther.
November 28–29	Falling	Normal	Mostly east	Norther begins *after* the disturbance.
December 3	Falling	Normal	Northeast and east.	
December 21	Normal	Large descent.	North	A norther.

List of northers with no magnetic disturbances accompanying, with an analysis of a few special coincidences.

October, 1872.—The grand magnetic disturbance, continuing from the 14th to the 18th, was simultaneous with a similar disturbance in Europe, supposed to be caused by a violent eruption on the sun. The disturbance in the magnetic curves is presumably not dependent upon the norther of the 14th and 15th, though simultaneous with it. On the 24th all the atmospheric conditions, except the pressure, indicate a norther, but no magnetic perturbation occurs.

November 1872.—15th and 16th, all the elements of a norther are present in great force. Beginning with a norther on the 15th the curve of the bifilar shows rapid oscillations, but, in general, of small range, with a steady upward tendency until the 23d, when there is a straight and rapid descent in the curve, coinciding with the ending of the north wind, followed by calm. A break in this wind occurred on the 23d, with calm or light east wind, during fourteen hours, not indicated by the magnet in any way, as far as shown by the observations. An oscillation on the 18th is sufficient to be classed as a disturbance. 28th, all the atmospheric conditions show a norther of great violence; no magnetic perturbation either at its beginning or during its continuance.

December, 1872.—12th, all the conditions of a norther are present, but no perturbation occurs. 26th, a violent norther, but the oscillation of the bifilar is not of sufficient range to be classed as a disturbance.

January, 1873.—16th, the conditions of a norther are present, but no magnetic disturbance occurs. 17th, the norther is renewed and continues till the 19th; a small magnetic perturbation takes place on the 17th, followed by a large disturbance on the 18th, coincident with a brilliant aurora. 31st, a norther but no magnetic perturbation takes place.

April, 1873.—A norther, beginning on the 17th, is accompanied on the 18th and 19th by violent disturbances in the bifilar magnetometer, coincident with brilliant and extensive auroras.

October, 1873.—On the 7th and 8th all the conditions of a norther—wind, temperature, pressure, tension of vapor, and humidity—are present, but no magnetic disturbance takes place. On the 19th all the meteorological elements show a norther; the curve of the bifilar contains no violent disturbance on this day, but shows a gradual rise until the 21st, when a direct descent of nineteen scale divisions takes place, some hours before the ending of the norther. Cold north wind blows from the 28th to the 31st, with velocity of 18 miles per hour, no perturbation accompanying.

November, 1873.—A violent norther on the 19th and 20th; the disturbance of the bifilar is very small, having a range of only thirteen scale divisions, followed by a condition of extreme quiescence on the 20th. The magnetic conditions accompanying the norther of the 28th and 29th are similar to those of November 15, 1872, and October 19, 1873, namely, a gradual rise in the bifilar curve begins with the advent of the norther and continues till near the end of the north wind, when a rapid descent takes place.

December, 1873.—26th, all the atmospheric conditions show a strong norther; the magnetic disturbance is very small. The conditions of a norther are renewed on the 28th, without magnetic disturbance.

January, 1874.—6th, 7th, and 8th, cold northwest wind, preceded by south, with all the atmospheric conditions of a norther, but the magnetic curve shows no disturbance.

February, 1874.—A norther beginning on the 8th continues through the 10th. The magnetic curve shows no disturbance at its advent, but a perturbation takes place a few hours before its ending.

April, 1874.—All the elements of a norther are present on the 10th, but without a magnetic disturbance accompanying; the bifilar curve shows, however, a rise at the beginning of the norther and gradually ascends till its ending, when a descent takes place. The second norther of the month reaches Havana on the 25th, and its effect on the meteorological records is evident until the 28th. The magnetic curve shows an action similar to that occurring during the norther of the 10th.

May, 1874.—A norther begins on the 5th and continues three days. The bifilar shows a continued disturbance from the 3d to the 6th, inclusive, of the same character before the arrival of the norther as after its appearance.

November, 1874.—A small norther is apparent on the 19th and 20th. The magnetic range on the 20th is sufficiently large to be classed as a perturbation, but the disturbance is by no means well marked, nor is it simultaneous with the beginning of the norther. A norther on the 25th and 26th is accompanied by a small disturbance on the 26th. The motion of the bifilar on the 27th and 28th, when no norther is present, is the same in character as that on the 25th and 26th. A norther on the 29th and 30th; no magnetic disturbance.

December, 1874.—A norther on the 7th and 8th is very well defined by the indications of all the meteorological observations, but the bifilar curves show a condition of extreme quiescence.

In order to draw any satisfactory conclusions from the conflicting data contained in the preceding tables the different phenomena must be collated and a numerical result obtained. Before this can be done, however, the treatment of the special cases given on page 10, for which no provision has been made, must be decided upon. In the examination of the magnetic bifilar curves as recorded during the presence of northers, a number of cases are observed, in which the curves, although not presenting fluctuatious of sufficient magnitude to be termed a disturbance by the method adopted, show a gradual rise, corresponding to an increase of magnetic force, beginning with the norther and continuing till near its ending, when a rapid descent takes place. This peculiar rise and descent, though not described by Viñes, has received careful attention in order to discover any uniformity in its occurrence; out of the whole number of northers five were found accompanied by this magnetic action.

These cases, as well as those in which a large range was coincident with the beginning of the norther, are considered to show a disturbed condition of the terrestrial magnetism; but as they seem to be a distinct manifestation they are classed separately in the following summary, Table III.

This summary gives a total of thirty-eight northers, twenty-seven of which are accompanied by abnormal magnetic curves leaving eleven northers which occur without any connection, direct or indirect, with magnetic disturbance, the bifilar curves presenting only the normal daily oscillations.

The larger portion of the northers are thus found to be coincident with magnetic perturbations. The question now arises—what do these coincidences show? Do they, as Viñes would have us believe, give sufficient reason to suppose a physical connection between the two phenomena? As an answer to this question it is my purpose to suggest certain considerations obtained from the internal evidence of the observations themselves, which tend to render many of the above coincidences of very doubtful significance.

In concluding a recent paper on terrestrial magnetism*, Prof. A. Oberbeck writes: "If we once more look over all the phenomena just described, we find that the freely suspended needle owes its position of equilibrium to the combined action of a great number of different causes. The earth's magnetism proper, whose locus is beneath the earth's surface, the sun, perhaps affected in its action by the momentary con-

* Die zeitlichen Veränderungen des Erdmagnetismus. Halle, 1881.

dition of its surface, the moon, earth currents, auroras—all these must be taken into consideration in determining the resultant directing force which acts upon the magnetic needle."

This resumé of Prof. Oberbeck presents very forcibly the complexity of the oscillations of the magnetic needle and the extreme difficulty of their accurate and complete analysis.

TABLE III.—*Summary by months of northers and magnetic disturbances at Havana.*

Date.	Number of days magnetic disturbance of large range.	Total number of northers.	Northers accompanied by perturbations of large range.	Northers accompanied by gradual rise.
1872.				
October	13	2	1	
November	14	2	0	1
December	9	3	1	
1873.				
January	13	6	4	
February	11	2	2	
March	13	2	2	
April	10	1	1	
May	9	1	1	
October	2	2	0	1
November	5	3	2	1
December	6	3	2	
1874.				
January	8	1	0	
February	5	1	1	
March	7	1	1	
April	7	2	0	2
May	8	1	1	
November	8	3	2	
December	2	2	1	
Total	150	38	22	5

In attempting to verify the supposed relation of an additional phenomenon as an occasion of magnetic perturbation, care should be taken that the observations are freed from the effect of all other sources of disturbance. We can not obtain a satisfactory conclusion unless the observations can be so arranged that the mean of a long series will eliminate everything except the relation in question or else perturbations due to other independent causes can be thrown out.

In the present investigation the period of observation is so short that the totals given in Table III. may present a wholly misleading result, wherefore the only course remaining is to separate from the coincidences in the above summary all those which a study of the observations gives us reason to believe are accidental—the disturbances being traceable to causes independent of the accompaying norther.

Of these cases we notice:

First. The coincidence of October, 1872, in which the magnetic disturbance is due to a violent eruption on the surface of the sun, the disturbance being very remarkable in intensity and duration, and occurring simultaneously over the whole world.

Second. In the attempt to separate the magnetic disturbances into separate classes, according to the character of the phenomenon, for the purpose of better analyzing the forces acting upon the needle, the perturbations occurring with auroras, and which I will call "auroral," are especially distinct in their action and have well marked characteristics. In general the two phenomena were proportional in inten-

sity—the more extensive and brilliant the aurora, the more violent was the disturbance of the magnet.

In a portion of the coincidences between northers and magnetic disturbances the latter are of this "auroral" character.

Viñes, in explanation of the causes of his concluded relation, considers that the warm, moist, atmospheric currents, preceding a norther, are charged with electricity, and, after reaching high latitudes, are productive of auroras. If this be the case, coincidences between northers and auroras should occur and the "auroral" magnetic disturbance can not be considered to be independent of the norther. In fact the norther would have a well-defined relation as a concomitant of these phenomena.

That this supposition, however, is not well founded is apparent from the large number of northers occurring with no proximity to auroras and of auroras occurring with no relation to northers. Of the whole number of northers about twenty-three per cent. are accompanied by auroras, and if we take the percentage for the last year and a half of the observations, after the maximum of auroral frequency is past, this proportion is but ten per cent., indicating that the coincidences are accidental and due to the large number of auroras.

Furthermore the primary supposition, that the moist southerly currents are charged with electricity arising from evaporation over the Gulf of Mexico, is not supported by recent experiments.*

As far as observations extend, therefore, the evidence is against a connection of auroras and northers, and accordingly all the auroral magnetic disturbances should be separated from the table of coincidences.

Third. We notice a few instances in which a prolonged disturbance occurs, of the same character and intensity as during its continuance, before the arrival of the norther or after its ending; the advent of the norther apparently causing no change in the movement of the needle. Three of the coincidences given above, namely, those of February 10, May 5, and November 25, 1874, exhibited this characteristic to such a degree that they were considered to be very poor evidence of the supposed relation to the northers of those dates. I accordingly add them to the list of coincidences, which a close analysis makes of doubtful value in supporting this hypothesis.

Fourth. In addition to the northers treated by these considerations, there are periods in which the large numbers of magnetic perturbations renders an accidental coincidence with a norther so probable that such coincidences as occur at these times can not of course furnish any ground for supposing a physical relation. These should be eliminated, if possible.

The general problem to be solved is as follows:

In a total of n days two events occur, the one on a days, the other on b days; what is the probability that they will occur together on k days, or, in other words, that there will be k coincidences. This problem gives rise to the following formula based on the principles of the doctrine of chances: The probability, P, of k coincidences of a norther days with b magnetic perturbations, in a total of n days is

$$P = \frac{\lfloor a \quad \lfloor n-a \quad \lfloor b \quad \lfloor n-b}{\lfloor a-k \quad \lfloor k \quad \lfloor b-k \quad \lfloor n \quad \lfloor n-a-(b-k)}$$

in which $\lfloor a$ represents the continued product of the series of numbers from a to 1.

* Mr. S. H. Freeman, after very careful experiments at the Johns Hopkins University, obtained the result that "evaporation is at most a very insignificant source of the atmospheric electricity." (See American Journal of Science, third series, vol. 23, 1882, p. 428.) The same result has been obtained in still more recent experiments by Blake, Kalischer, and others. In a paper read before the Scottish Meteorological Society, March 17, 1884, Prof. Tait reviews the evaporation theory and other attempts to account for the origin of atmospheric electricity, and decides that experiments must be made on a far larger scale than heretofore attempted, before any real success in the solution of the problem can be attained.

It will be seen that the two events a and b enter the formula symmetrically as they should. The formula assumes an equal distribution of the two phenomena. But since the frequency of magnetic storms and of northers is not uniform for any considerable period of time, we are limited in its application to a value of n for which we may consider that the frequency will be practically constant. A month has been taken as the period for which this may be assumed; n will therefore be the number of days in each month; the values of a and b for any given period can be obtained from the preceding summary. With these values of a, b, and n, substitute now different values for k, from o to a, and compute the probability corresponding to each separate value. If now the observed number of coincidences is no greater than the number for which the computed probability, P, is a maximum, then they must be considered as accidental.* Thus, for December, 1872, it is shown that there is a maximum probability in favor of the coincidence in that month. Of three northers and nine days of disturbance, the probability of three coincidences is .02; of two coincidences, .18; of one coincidence, .46; of no coincidences, .34. The existing condition, that of one coincidence, is therefore that of maximum probability. This should accordingly be deducted from the total number of coincidences, in order to leave only those from which a physical connection can be inferred.

The twenty-two coincidences are thus, by the preceding analysis, reduced to eight cases which can be used to sustain the supposed relation between magnetic and atmospheric phenomena. It is, moreover, reasonable to suppose that if our data of auroras, solar eruptions, and other magnetic and electrical phenomena were more extended *some of these eight* would also be found due to such phenomena.

To recapitulate; after having separated those from which no conclusion can be inferred, we have found eleven northers producing no perturbations in the terrestrial magnetism at Havana; eight accompanied by large fluctuations which have not been traced to other sources for their origin; and five accompanied by a gradual rise in the bifilar curve, followed by a sharp descent near their ending. It is from these five that a connection is most likely to be found, if at all, but they are so few in number, relatively to the whole number of northers, that it would seem we must look still further for the explanation of their origin.

The present investigation can not, on account of the limited data at hand, be considered to furnish a conclusive answer to the question of a connection or correllation between northers and magnetic disturbances, but it simply aims to inquire whether the hypothesis of Viñes is well supported by a careful analysis of the observations upon which it is based and upon which it rests for its justification.

Though the evidence of a direct connection between northers and magnetism appears inconclusive, we have reason to believe, that some of the smaller magnetic variations, especially in horizontal force, may be due to the electric conditions of the atmosphere. That magnetic perturbations take place with a given distribution of pressure has been maintained, in an elaborate and carefully prepared memoir by Forssman,† and from the results of a long series of observations a connection between magnetic disturbances and the scintillation of the stars has been set forth by Montigny.‡ These discussions increase the belief that some, at least, of the many variations in the position of the magnetic needle may yet be successfully correlated with meteorological phenomena.

* If we differentiate the formula, considering k as a variable, we find that P is a maximum when $k = \frac{a\,b}{n}$. Hence this equation can be used to obtain k instead of the original formula.

† Forssman, L. A. Des relations de l'Aurore Boréale et des perturbations magnétiques avec les phénomènes météorologiques. [1871.]

‡ Bulletin de l'Academie Royale des Sciences de Belgique. December, 1883.

APPENDIX.

Since the preceding paper was in type the volume of Havana observations for 1875 has been received. In completion of the paper, a short summary of the additional data therein contained has been compiled and is here presented.

The period of maximum sun spots having passed, and consequently the number of magnetic disturbances being fewer, the observations for this year are much more valuable and satisfactory for ascertaining the relation between northers and magnetic disturbances than those already discussed, for years in which the magnetic needle was for long periods in a continuous state of disturbed oscillation. The year 1875 opens with a state of extreme quiescence, not only in the magnetic, but also in the atmospheric elements. During the months of January and February only two well-defined northers are recorded, and the mean temperture of both months is accordingly unusually high. This concomitant lack of disturbance in the atmospheric and magnetic conditions raises the question, whether it is only an accidental coincidence, or whether a well-defined eleven-year period exists also in the frequency of northers.

In the foregoing paper the form of the argument is based on the implied assumption that no sensible eleven-year periodicity in the frequency or severity of northers can be detected, or that, if such a period exists, it is so slight as to be appreciable only in the mean of many years' observations. This same view has been recently expressed by Prof. C. A. Young, as follows: "I am more than sceptical whether the terrestrial influence of sun spots amounts to anything worth speaking of, except in the direction of magnetism."†

Assuming that the monthly mean temperature is a fair test of the occurrence of northers, any indications of an eleven-year periodicity may perhaps be noted in the following table of winter temperatures from 1863 to 1875, inclusive:

Monthly mean temperature, at Havana. Centigrade.

	Jan.	Feb.	Mar.	Apr.	Nov.	Dec.	Mean.
1863	20.8	23.0	23.9	25.1	25.0	22.3	23.3
1864	22.7	22.2	24.0	24.6	24.6	23.8	23.6
1865	21.3	22.2	25.2	26.0	23.8	24.0	23.7
1866	22.3	23.1	23.3	25.6	23.8	23.1	23.5
1867	22.4	24.4	26.5	26.8	25.1	24.0	24.9
1868	24.1	22.8	24.6	27.2	24.3	22.2	24.2
1869	23.9	24.0	24.7	26.9	23.8	23.1	24.4
1870	23.8	21.8	24.3	24.4	23.5	22.5	23.4
1871	21.9	23.5	25.2	26.4	25.4	23.4	24.3
1872	21.9	22.3	23.9	26.9	24.8	23 2	23.8
1873	22.4	23.7	23.3	25.5	24.0	23.2	23.7
1874	21.8	23.9	25.1	26.6	24.8	23.0	24.2
1875	23.9	23.9	25.3	24.6	25.5	23.5	24.4

The means in this table, with the exception of the years 1866 and 1871, seem to indicate a tendency towards a maximum temperature at the epoch of minimum sun spots and a minimum temperature at the epoch of maximum sun spots. The two years, 1866 and 1871, though close to the times of maximum and minimum, entirely fail to conform to the periodicity indicated by the others.

List of northers at Havana during 1875.

January, 1875.—A norther on the 31st; magnetic disturbance on the 30th. Four days of magnetic disturbance in the month.

†Address of the retiring president, American Association for the Advancement of Science, Philadelphia meeting, Sept., 1884.

February, 1875.—A norther on the 7th; small magnetic disturbance and aurora. Eight days of magnetic disturbance in the month.

March, 1875.—A norther on the 7th; magnetic disturbance and auroras. A norther on the 17th with magnetic disturbance. A norther on the 22d; no magnetic disturbance. Nine days of magnetic disturbance in the month.

April, 1875.—A norther on the 3d without magnetic disturbance. A norther on the 13th with magnetic disturbance. A norther on the 23d without magnetic disturbance. A norther on the 27th without magnetic disturbance. Five days of magnetic disturbance in the month.

May, 1875.—A norther on the 5th; the magnetic curves show a continued disturbance through the first thirteen days of the month during the prevalence of successive auroras.

October, 1875.—A slight norther on the 11th; a magnetic disturbance takes place on the 12th. A norther on the 16th without magnetic disturbance. A norther on the 23d; a magnetic disturbance on the 24th accompanies an aurora. Six days of magnetic disturbance in the month.

November, 1875.—A severe norther on the 11th without magnetic disturbance. Four days of magnetic disturbance in the month.

December, 1875.—A severe norther on the 7th continues till the 11th; a magnetic disturbance on the 6th. A norther on the 17th with magnetic disturbance. Six days of magnetic disturbance in the month.

In the above list of northers the magnetic disturbances occurring on the day preceding a norther, the day of its occurrence, or the day following, are carefully noted. In determining the probable occurrence of a magnetic disturbance at the time of a norther, the degree or closeness of the coincidence that is desired must be considered. Thus, if it is desired to determine the probable number of magnetic disturbance that will occur either on the day preceding a norther, or on the day of its advent, for the month of December, we have $k = \frac{6 \times 4}{31}$; one magnetic disturbance may, therefore, be expected to occur by chance on one of these days.

From an inspection of the list of northers, the results of the observations for the year 1875, may be summarized as follows:

1. For January, February, March, October, and December, the number of magnetic disturbances occurring near the times of northers is greater than can be accounted for by chance.

2. The time of such disturbances varies from the day preceding the norther to the day following the norther.

3. Numerous and severe northers occur without being accompanied by disturbances in the magnetic instruments.

From the last two of these facts we may conclude that the connection between northers and magnetic disturbances exhibited by the first is not direct, but incidental. The occurrence of a norther is not the sufficient condition of a magnetic disturbance, and therefore no prediction of one from the presence of the other is possible. The general connection, maintained by Father Viñes and sustained by our analysis of this year and the preceding years, namely, the frequent occurrence of magnetic disturbances at or near the advent of northers, still remains to be explained. This connection can, perhaps, be sufficiently and satisfactorily accounted for by the investigation of Forssman, already referred to. Dr. Forssman finds, from the mean of many observations at Toronto, that auroras and magnetic perturbations have a tendency to occur on the day after the passage of a low barometer at that place. They are consequently coincident with the advance over the southern states of areas of high pressure, which in the winter season are termed northers.

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SIGNAL OFFICE, WAR DEPARTMENT.

SIGNAL SERVICE NOTES,

No. XIV,

SUPPLEMENT TO SIGNAL SERVICE NOTES, No. X.

PHYSICAL OBSERVATIONS

DURING THE

LADY FRANKLIN BAY EXPEDITION

OF

1883.

PREPARED UNDER THE DIRECTION OF

BRIG. AND BVT. MAJ. GEN. W. B. HAZEN,
Chief Signal Officer of the Army,

BY

W. H. LAMAR, Jr., A. B., and FRANK W. ELLIS, A. B.,
Sergeants, Signal Corps, U. S. A.

BY AUTHORITY OF THE SECRETARY OF WAR.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1884.

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SIGNAL SERVICE, U. S. A.

No. XIV.

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1884.

936——No. XIV

1885, March 6,
Gift of
the Signal Office.

NOTE.

This number of Signal Service Notes is published as a supplement to Signal Service Notes, No. X. It contains the notes of physical observations on board the vessels of the Relief Expedition to Lady Franklin Bay, 1883, made by Privates (now Sergeants) Lamar and Ellis, Signal Corps, and notes of magnetic observations made by the same parties at Saint John's, Newfoundland, and Upernavik, Greenland.

LETTER OF TRANSMITTAL.

WAR DEPARTMENT, OFFICE OF THE CHIEF SIGNAL OFFICER,
Washington City, December 13, 1883.

SIR: I have the honor to respectfully submit the following report of the work of the Signal Service observers, under your command, on the Lady Franklin Bay Relief Expedition of 1883.

The report embraces:

I.—Regular meteorological observations, from June 13 until the wreck of the Proteus, and extracts from observers' journal, which was continued until the Yantic was reached, August 31. Washington mean time was always recorded.

II.—Magnetic observations at Saint John's, Newfoundland, and Godhavn, Greenland.

III.—A chart, with course of the Yantic from New York to Saint John's, and course of the Proteus from Saint John's to the place where she sank, with the approximate position of vessel at each meteorological observation. The chart also contains the courses of the boats on the retreat.

IV.—While on the Yantic, a copy of ship's log, containing hourly meteorological observations, was made daily by your observers and is inclosed herewith.*

V.—A copy of the meteorological records of Upernavik for 1882 and 1883 is also inclosed.*

Very respectfully, your obedient servant,

W. H. LAMAR, JR.,
Sergeant, Signal Corps, U. S. A.

Lieut. E. A. GARLINGTON.

WASHINGTON, D. C., *December* 16, 1883.

Respectfully forwarded to the Chief Signal Officer.

E. A. GARLINGTON,
First Lieutenant, Seventh Cavalry, Acting Signal Officer.

* Not published with these notes.

1885. Mar. 6.

Chief

The Signal Office.

REPORT.

JUNE 11–12.

Left Washington, D. C., at 9.50 p. m., June 11, with instruments. Ellis and Lamar carried by hand two chronometers each, and the four mercurial barometers were carried by Corporal Elwell and Private Moritz. Every precaution was taken to insure the transportation of these instruments, by rail, without injury, to New York, where they were, on June 12, carefully placed on board the U. S. S. Yantic.

LAMAR, *Observer.*

BROOKLYN NAVY-YARD, *June* 13.

Signal Service barometers not yet being mounted, begun observations with ship's barometer (no number), ship's exposed thermometer (S. S., No. 462), and wet-bulb thermometer (S. S., No. 463). These thermometers were used up to and including the 11 a. m. observation of June 21.

Mean time chronometer, No. 1683, compared with the time ball at New York by Private Ellis.

1683, fast on Washington mean time 1m 31.9s
1691, fast on Washington mean time 2 33.3
1692, fast on Washington sidereal time 6 19.7
1693, fast on Washington sidereal time 4 03.0

Rain began at 6 p. m.

LAMAR, *Observer.*

ON BOARD THE YANTIC.

JUNE 13, 1883.

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.										
7 a. m.										
11 a. m.										
3 p. m.										
7 p. m.	40 50	73 45	29.737		68	67.5	67	97	N.	Light.
11 p. m.	41 10	72 50	29.787		66	66	66	100	NE.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.									
7 a. m.									
11 a. m.									
3 p. m.									
7 p. m.	Hidden.			10	Nim.	N.		Light rain.	Lamar.
11 p. m.	Hidden.			10	Nim.	NE.		Light rain.	Lamar.

JUNE 14.

Rain ended at 2 a. m. Marine barometers, No. 520 and No. 521, were mounted by the side of ship's barometer in the armory. The cisterns of barometers were 6 feet above sea-level. The following comparisons were made:

Time.	Attached thermometer.	Barometer No. 521.	Attached thermometer.	Barometer No. 520.	Attached thermometer.	Ship's barometer.	Observer.
	°		°		°		
12 m	63.5	30.174	63.5	30.174	64.8	30.131	Lamar.
1 p. m	65.5	30.184	65.5	30.184	67	30.151	Lamar.
2 p. m	66	30.194	66	30.196	67.4	30.163	Lamar.

The difference of temperature indicated between the attached thermometer of the ship's barometer and those of the two Signal Service barometers is due to an error of the thermometer of the ship's barometer. A comparison between the standard chronometer 1691 and the ship's standard chronometer gave a discrepancy of 1.9 seconds. Barometer No. 521 used for 3 p. m. observation.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m	41 15	72 08	29.821	.....	61	57	54	78	NE.	Light.
7 a. m	41 20	71 25	29.982	.....	58 2	55.8	53.4	85	N.	Fresh.
11 a. m	41 26	70 50	30.077	.....	63.2	57	51.8	67	NE.	Fresh.
3 p. m	41 30	70 40	30.088	.....	65.8	57	49.2	55	NE	Light.
7 p. m	41 30	70 40	30.145	.....	63.8	58.5	54.2	72	NE.	Light.
11 p. m	41 30	70 40	30.202	.....	60	56.3	52.6	77	NW.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m	0	0	0	9	Strat ..	NE.	.....	Cloudy	Lamar.
7 a. m	0	0	0	8	Cu.-st ..	N.	.....	Cloudy	Ellis.
11 a. m	2	Ci.-st...	NE.	0	0	0	.....	Clear	Ellis.
3 p. m	0	0	0	0	0	0	.....	Clear	Ellis.
7 p. m	0	0	0	0	0	0	.....	Clear	Ellis.
11 p. m	0	0	0	0	0	0	.....	Clear	Ellis.

JUNE 15.

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m	41 30	70 40	30.102	.....	58.6	56.2	53.8	85	N.	Light.
7 a. m	41 30	70 40	30.266	.....	64	60	57	84	N.	Light.
11 a. m	41 30	70 40	30.294	.....	64	59	55	73	NE.	Light.
3 p. m	41 25	70 08	30.266	.....	64	61	59	84	E.	Light.
7 p. m	41 48	68 49	30.256	.....	61	57	54	78	SE.	Light.
11 p. m	42 00	68 05	30.279	.....	59	56	53	81	E.	Light.

Washington time.	Clouds. Upper. Amount.	Kind.	Direction.	Lower. Amount.	Kind.	Direction.	Water temperature.	State of weather.	Observer.
							°		
3 a. m.	0	0	0	0	0	0	.....	Clear.....	Ellis.
7 a. m.	0	0	0	0	0	0	.....	Clear.....	Lamar.
11 a. m.	0	0	0	0	0	0	.....	Clear.....	Lamar.
3 p. m.	0	0	0	0	0	0	.....	Clear.....	Lamar.
7 p. m.	0	0	0	0	0	0	.....	Clear.....	Lamar.
11 p. m.	0	0	0	0	0	0	.....	Clear.....	Lamar.

JUNE 16.

Washington time.	Position. Latitude.	Longitude.	Barometer. Actual.	Reduced.	Thermometer. Dry bulb.	Wet bulb.	Dew-point.	Relative humidity.	Wind. Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	42 13	67 27	30.304	.....	57	54	51	80	E.	Light.
7 a. m.	42 17	66 54	30.315	.....	55	52.1	49.2	81	E.	Fresh.
11 a. m.	42 32	66 15	30.310	.....	56.4	53.2	50	79	E.	Fresh.
3 p. m.	42 36	65 46	30.223	.....	56.7	52.8	48.9	75	E.	Fresh.
7 p. m.	42 42	65 10	30.236	.....	55.3	52.5	49.7	81	E.	Fresh.
11 p. m.	42 48	64 32	30.199	.....	54.8	53.2	51.6	89	E.	Fresh.

Washington time.	Clouds. Upper. Amount.	Kind.	Direction.	Lower. Amount.	Kind.	Direction.	Water temperature.	State of weather.	Observer.
							°		
3 a. m.	0	0	0	0	0	0	.....	Clear	Lamar.
7 a. m.	3	Ci.-st ..	E.	0	0	0	.....	Clear	Ellis.
11 a. m.	2	Cir	E.	0	0	0	.....	Fair	Ellis.
	3	Ci.-st ..	E.						
3 p. m.	3	Cir	E.	0	0	0	.....	Fair	Ellis.
	2	Ci.-st ..	E.						
7 p. m.	2	Ci.-st ..	E.	0	0	0	.....	Clear	Ellis.
11 p. m.	2	Ci.-st ..	E.	0	0	0	.....	Clear	Ellis.

JUNE 17.

Fair weather in morning and foggy in the afternoon. Fog-bow observed.

LAMAR, *Observer.*

Washington time.	Position. Latitude.	Longitude.	Barometer. Actual.	Reduced.	Thermometer. Dry bulb.	Wet bulb.	Dew-point.	Relative humidity.	Wind. Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	42 53	63 55	30.200	.....	54.2	53	51.8	92	E.	Light.
7 a. m.	42 58	63 18	30.199	.....	58	54	50	74	E.	Light.
11 a. m.	43 05	62 40	30.206	.....	58	54	50	74	E.	Light.
3 p. m.	43 12	62 10	30.189	.....	56	53	50	80	E.	Light.
7 p. m.	43 20	61 36	30.143	.....	50	49	48	93	E.	Light.
11 p. m.	43 28	61 02	30.149	.....	50	49	48	93	E	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.....	1	Ci.-st ..	0	0	0	0	.....	Clear	Ellis.
7 a. m.....	0	0	0	0	0	0	.....	Clear	Lamar.
11 a. m.....	0	0	0	0	0	0	.....	Clear	Lamar.
3 p. m.....	0	0	0	0	0	0	.....	Clear	Lamar.
7 p. m.....	Hidden.	.....	.....	10	Strat ...	0	.....	Cloudy	Lamar.
11 p. m.....	Hidden.	.....	.....	Dense..	Fog	0	.....	Foggy	Lamar.

JUNE 18.

Cloudy and foggy weather. A lunar halo was seen at 7 p. m. and measured with a sextant. It gave a radius of 6 degrees.

ELLIS, *Observer*.

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m	43 35	60 27	30.167	.....	50	49.5	49	96	E.	Light.
7 a. m.....	43 43	59 51	30.187	.....	50.5	50.2	49.9	96	NE.	Light.
11 a. m.....	43 51	59 18	30.165	.....	54.2	52.4	50.6	88	E.	Light.
3 p. m.....	44 05	58 42	30.131	.....	52.7	51.6	50.5	92	NE.	Light.
7 p. m.....	44 17	58 01	30.139	.....	46.6	46.6	46.6	100	NE.	Light.
11 p. m.....	44 32	57 26	30.109	.....	50	49.2	48.4	94	NE.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.....	Hidden.	.....	.....	Dense .	Fog ...	.....	.....	Foggy	Lamar.
7 a. m.....	Hidden.	.....	.....	Dense .	Fog ...	.....	.....	Foggy	Ellis.
11 a. m.....	Hidden.	.....	.....	Light.. 10	Fog ... Strat ..	.....	.....	Cloudy	Ellis.
3 p. m.....	Hidden.	.....	.....	Dense .	Fog ...	.....	.....	Foggy	Ellis.
7 p. m.....	0	0	0	Light..	Fog ...	.....	.....	Clear	Ellis.
11 p. m.....	Hidden.	.....	.....	Light.. 10	Fog ... Strat ..	.....	.....	Cloudy	Ellis.

JUNE 19.

Cool, foggy weather, with an occasional glimpse of the sun in the morning.

LAMAR, *Observer*.

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.....	44 45	56 45	30.115	.....	50	49.2	48.4	94	E.	Light.
7 a. m.....	44 58	56 12	30.131	.....	46.5	46.5	46.5	100	NE.	Light.
11 a. m.....	45 11	55 34	30.115	.....	46.5	46.5	46.5	100	NE.	Light.
3 p. m.....	45 23	55 06	30.105	.....	49	48	47	93	NE.	Light.
7 p. m.....	45 39	54 42	30.141	.....	50	49	48	93	NE.	Light.
11 p. m.....	45 56	54 14	30.133	.....	44	43	42	93	NE.	Light.

Washington time.	Clouds. Upper. Amount.	Kind.	Direction.	Lower. Amount.	Kind.	Direction.	Water temperature.	State of weather.	Observer.
							°		
3 a. m	Hidden			Dense	Fog			Foggy	Ellis.
7 a. m	Hidden			Dense	Fog			Foggy	Lamar.
11 a. m	0	0	0	Light	Fog			Clear	Lamar.
3 p. m	Hidden			Dense	Fog			Foggy	Lamar.
7 p. m	Hidden			Dense	Fog			Foggy	Lamar.
11 p. m	Hidden			Dense	Fog			Foggy	Lamar.

JUNE 20.

Very heavy fog in morning, wetting the decks of the vessel. Not so heavy overhead at 11 a. m., but very dense in the horizon.

ELLIS, *Observer.*

Washington time.	Position. Latitude.	Longitude.	Barometer. Actual.	Reduced.	Thermometer. Dry bulb.	Wet bulb.	Dew-point.	Relative humidity.	Wind. Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m	46 11	53 45	30.156		44	44	44	100	NE.	Light.
7 a. m	46 27	53 19	30.203		44.3	44.3	44.3	100	NE.	Fresh.
11 a. m	46 43	52 48	30.240		46	45.3	44.6	95	NE.	Fresh.
3 p. m	46 50	52 42	30.263		45.3	44.3	43.3	93	NE.	Fresh.
7 p. m	46 54	52 39	30.287		41.2	41.2	41.2	100	E.	Light.
11 p. m	46 58	52 35	30.303		41.7	41.7	41.7	100	E.	Light.

Washington time.	Clouds. Upper. Amount.	Kind.	Direction.	Lower. Amount.	Kind.	Direction.	Water temperature.	State of weather.	Observer.
							°		
3 a. m	Hidden			Dense	Fog			Foggy	Lamar.
7 a. m	Hidden			Dense	Fog			Foggy	Ellis.
11 a. m	Hidden			Dense	Fog			Foggy	Ellis.
3 p. m	Hidden			Dense	Fog			Foggy	Ellis.
7 p. m	Hidden			Dense	Fog			Foggy	Ellis.
11 p. m	Hidden			Dense	Fog			Foggy	Ellis.

SAINT JOHN'S, NEWFOUNDLAND, *June* 21.

Anchored in the harbor of Saint John's, Newfoundland, at 2 p. m. Instruments were carried to Queen's Hotel, but shortly afterward the chronometers and barometer No. 521 were carried on board the Proteus and barometer mounted in captain's room. All other instruments had been stored away with ship's cargo several days before the arrival of the Yantic; 3 p. m. observation was not made, observer being engaged moving instruments.

LAMAR, *Observer.*

Washington time.	Position. Latitude.	Longitude.	Barometer. Actual.	Reduced.	Thermometer. Dry bulb.	Wet bulb	Dew-point.	Relative humidity.	Wind. Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m	47 09	52 34	30.279		41	41	41	100	SE.	Light.
7 a. m	47 14	52 32	30.247		43.5	43.5	43.5	100	NE.	Light.
1 a. m	47 19	52 28	30.286		48	47	46	93	NE.	Light.
3 p. m										
7 p. m	47 34	52 41	30.260						E.	Light.
11 p. m	47 34	52 41	30.228						NE.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.	Hidden.	.....	.....	Dense.	Fog.	.....	.....	Foggy	Ellis.
7 a. m.	Hidden.	.....	.....	Dense.	Fog.	.....	.....	Foggy	Lamar.
11 a. m.	Hidden.	.....	.....	Dense.	Fog.	.....	.....	Foggy	Lamar.
3 p. m.	.....	.....	.....	.....	.....	.....	.....	.....	.....
7 p. m.	0	0	0	9	Strat.	E.	.....	Cloudy	Lamar.
11 p. m.	0	0	0	9 Light.	Strat. Fog.	NE.	.....	Cloudy	Lamar.

ON BOARD THE PROTEUS.

SAINT JOHN'S, NEWFOUNDLAND, *June* 22.

The cargo was broken out and the necessary instruments and stationery supplies found. Put together two instrument shelters and placed them on after deck on opposite sides of the fore-companion-way and fastened them down upon scantling, bottom of shelter being four inches from the deck. No temperatures observed, thermometers not having been unpacked.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	47 34	52 41	30.271	.....	.....	.....	.....	.....	NE.	Light.
7 a. m.	47 34	52 41	30.188	.....	.....	.....	.....	.....	NE.	Light.
11 a. m.	47 34	52 41	30.148	.....	.....	.....	.....	.....	N.	Fresh.
3 p. m.	47 34	52 41	30.127	.....	.....	.....	.....	.....	N.	Light.
7 p. m.	47 34	52 41	30.108	.....	.....	.....	.....	.....	N.	Light.
11 p. m.	47 34	52 41	30.067	.....	.....	.....	.....	.....	0	Calm.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.	Hidden.	.....	.....	Dense.	Fog.	.....	.....	Foggy	Lamar.
7 a. m.	Hidden.	.....	.....	Dense.	Fog.	.....	.....	Foggy	Ellis.
11 a. m.	Hidden.	.....	.....	10 Light.	Strat. Fog.	N.	.....	Cloudy	Ellis.
3 p. m.	Hidden.	.....	.....	10 Light.	Strat. Fog.	N.	.....	Cloudy	Ellis.
7 p. m.	Hidden.	.....	.....	10 Light.	Strat. Fog.	N.	.....	Cloudy	Ellis.
11 p. m.	Hidden.	.....	.....	10 Light.	Strat. Fog.	N.	.....	Cloudy	Ellis.

SAINT JOHN'S, NEWFOUNDLAND, *June* 23.

Dense fog during the early portion of the morning, wetting the decks of the vessel. No temperatures observed till 7 p. m., thermometers not having been unpacked. During the day unpacked instruments, blanks, &c., and the following instruments were placed in the instrument shelter on starboard side of the vessel: exposed thermometer No. 1189; wet-bulb thermometer No. 1167; maximum thermometer No. 986; minimum thermometer No. 872. Rain began 10 p. m.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	47 34	52 41	30.075	.....	.....	.....	.....	.....	.....	Calm.
7 a. m.	47 34	52 41	30.068	.....	.....	.....	.....	.....	N.	Light.
11 a. m.	47 34	52 41	30.077	.....	.....	.....	.....	.....	NE.	Light.
3 p. m.	47 34	52 41	30.029	.....	.....	.....	.....	.....	NE.	Light.
7 p. m.	47 34	52 41	30.020	.....	53	52	51	93	0	Calm.
11 p. m.	47 34	52 41	29.981	.....	53	53	53	100	NE.	Calm.

Washington time.	Clouds. Upper. Amount.	Kind.	Direction.	Lower. Amount.	Kind.	Direction.	Water temperature.	State of weather.	Observer.
3 a. m	Hidden			Dense	Fog			Foggy	Ellis.
7 a. m	Hidden			Dense	Fog			Foggy	Ellis.
11 a. m	Hidden			10	Strat	0		Cloudy	Lamar.
3 p. m	Hidden			10	Nim	0		Lightrain	Lamar.
7 p. m	Hidden			10	Strat	0		Cloudy	Lamar.
11 p. m	Hidden			10	Nim	0		Lightrain	Lamar.

SAINT JOHN'S, NEWFOUNDLAND, *June* 24.

Clouds, principally cumulus and cumulo-stratus, hanging very low, and moving from the west and northwest with considerable velocity, though very little wind could be felt on deck. The high land around Saint John's cuts off the wind from every direction except the eastward.

ELLIS, *Observer*.

Washington time.	Position. Latitude.	Longitude.	Barometer. Actual.	Reduced.	Thermometer. Dry bulb.	Wet bulb.	Dew-point.	Relative humidity.	Wind. Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m	47 34	52 41	30.129		58	57	56	93	0	Calm.
7 a. m	47 34	52 41	29.818		52	51.8	51.6	98	0	Calm.
11 a. m	47 34	52 41	29.815		66.8	61.8	57.8	73	W.	Light.
3 p. m	47 34	52 41	29.855		67	61.1	56.2	67	W.	Light.
7 p. m	47 34	52 41	29.912		54.7	53.7	52.7	93	0	Calm.
11 p. m	47 34	52 41	29.959		56.1	55.8	55.5	98	S.	Light.

Washington time.	Clouds. Upper. Amount.	Kind.	Direction.	Lower. Amount.	Kind.	Direction.	Water temperature.	State of weather.	Observer.
							°		
3 a. m	Hidden			10	Strat	0		Cloudy	Lamar.
7 a. m	Hidden			10	Lt. fog / Strat	0		Cloudy	Ellis.
11 a. m	0	0	0	7	Cum	W.		Fair	Ellis.
3 p. m	3	Cir	SW.	4	Cum	NW.		Fair	Ellis.
7 p. m	Hidden			10	Strat	0		Cloudy	Ellis.
11 p. m	0	0	0	7	Cu.-st.	W.		Fair	Ellis.

SAINT JOHN'S, NEWFOUNDLAND, *June* 25.

Attempted to get sun-sights for chronometer correction in the morning, but clouds prevented. Marine barometer No. 520 was carried to the instrument store of Mr. J. A. Whiteford and placed in position for making comparisons. In the afternoon instruments were taken in a boat to Cape Spear, a well-determined position, to get sun-sights for chronometer correction. Three sets were taken by Private Ellis, when the sun became obscured by clouds. Did not return in time to take the 3 p. m. observation.

LAMAR, *Observer*.

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m	47 34	52 41	30.016	.....	59	58.8	58.6	98	S.	Light.
7 a. m	47 34	52 41	30.079	.....	66	64	63	90	NW.	Light.
11 a. m	47 34	52 41	30.100	.....	62	59	57	84	NE.	Light.
3 p. m	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7 p. m	47 34	52 41	30.200	.....	55	52	49	80	N.	Light.
11 p. m	47 34	52 41	30.207	.....	52	51	50	93	N.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m	3	Cir	NW.	4	Cum ...	W.	.....	Fair	Ellis.
7 a. m	Hidden.	.....	.....	10	Strat ..	N.	....	Cloudy ...	Lamar.
11 a. m	1	Cir	W.	4	Cum ...	SW.	.....	Fair	Lamar.
3 p. m	.....	.....	.....	.....	.....	.....	.....	.....	.....
7 p. m	0	0	0	0	0	0	.....	Clear	Lamar.
11 p. m	1	Cir ...	N.	0	0	0	.....	Clear	Lamar.

SAINT JOHN'S, NEWFOUNDLAND, *June* 26.

An attempt was made this morning to have the time of Greenwich mean noon sent by telegraph. From some cause the signal was not received. Another attempt was made at 1 o'clock and resulted in a similar failure. The time-sights, secured on the 25th, agree very well, and show that not enough had been allowed for the rate of the standard of comparisons.

The day was entirely cloudy. Clouds mostly stratus and calm. Gentle winds from northeast to east. Comparative readings of marine barometer No. 520, Mr. Whiteford's siphon barometer and aneroid barometer were taken, but, these instruments not having been used for meteorological observations, the comparisons were deemed of little value. There is no reliable barometer in Saint John's. John Delaney, meteorological observer, died some time since and his work is not continued.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m	47 34	52 41	30.247	.....	49.2	49.2	49.2	100	NE.	Light.
7 a. m	47 34	52 41	30.292	.....	49.5	49	48	94	NE.	Light.
11 a. m	47 34	52 41	30.331	.....	48.7	47.7	46.7	93	NE.	Light.
3 p. m	47 34	52 41	30.379	.....	47.7	46.8	45.9	94	NE.	Light.
7 p. m	47 34	52 41	30.391	.....	46.9	46	45.1	94	E.	Light.
11 p. m	47 34	52 41	30.368	.....	46.5	45.6	44.7	94	SW.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m	Hidden.	.....	.....	10	Nim ...	0	.....	Light rain .	Lamar.
7 a. m	Hidden.	.....	.....	10	Strat ..	0	.....	Cloudy	Lamar
11 a. m	Hidden.	.....	.....	10	Strat ..	0	.....	Cloudy	Ellis.
3 p. m	Hidden	.....	.....	10	Strat ..	NE.	.....	Cloudy	Ellis.
7 p. m	Hidden	.....	.....	10	Strat ..	0	.....	Cloudy	Ellis.
11 p. m	Hidden.	.....	.....	10	Strat ..	0	.....	Cloudy	Ellis.

Maximum: 50.6 at 3 p. m., 50.7 at 11 p. m. Minimum: 49.5 at 7 a. m., 45.9 at 11 p. m.

SAINT JOHN'S, NEWFOUNDLAND, *June 27.*

Magnetic instruments carried to Church Hill and mounted. Observations had just commenced (10.40 a. m.) when rain began, preventing a continuation of the work. Rain continued throughout the day. Succeeded in securing a correction to mean-time chronometer 1683 by telegraph from Greenwich this morning. It was found to be fast, on Washington mean time, $1^m\ 30^s.6$. The signal was a single click of the telegraph instrument sent from Greenwich at the instant of mean noon. This signal was repeated by an operator stationed at the American end of the cable to operator at Saint John's.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m	47 34	52 41	30.352	.....	46.3	45.7	45.1	95	SW.	Light.
7 a. m	47 34	52 41	30.287	.....	52.8	50.9	49	87	SE.	Fresh.
11 a. m	47 34	52 41	30.222	.....	50	50	50	100	SW.	Light.
3 p. m	47 34	52 41	30.025	.....	51	51	51	100	SW.	Light.
7 p. m	47 34	52 41	29.923	.....	56	56	56	100	SE.	Light.
11 p. m	47 34	52 41	29.864	.....	56.5	56.5	56.5	100	SE.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m	Hidden	.....	.....	10	Lt. fog, Strat.	0	.....	Cloudy	Ellis.
7 a. m	Hidden	.....	.....	10	Strat	S.	.....	Cloudy	Ellis.
11 a. m	Hidden	.....	.....	10	Nim	0	.....	Light rain	Lamar.
3 p. m	Hidden	.....	.....	10	Nim	0	.....	Light rain	Lamar.
7 p. m	Hidden	.....	.....	10	Nim	0	.....	Light rain	Lamar.
11 p. m	Hidden	.....	.....	10	Nim	0	.....	Light rain	Lamar.

Maximum: 54.0 at 3 p. m.; 59.0 at 11 p. m. Minimum: 45.8 at 7 a. m. and 11 p. m.

CHRONOMETER CORRECTION.

SAINT JOHN'S, NEWFOUNDLAND, *June 25–27.*

In the afternoon of 25th mean-time chronometer 1683 was carried to Cape Spear light-house and three sets of time sights secured.

SET. I.

Observed twice the altitude.	Chron. 1683. Washington mean time.	Remarks.
° ′ ″	*h. m. s.*	
Sun's lower limb..... 47 30 00	3 43 53.5	Weather cloudy; no shade glasses or cover for artificial horizon used.
47 20 00	3 44 23.5	
47 10 00	3 44 52.5	
Sun's upper limb..... 47 30 00	3 47 10.5	
47 20 00	3 47 41.0	
47 10 00	3 48 10.0	

ELLIS, *Observer.*

SET II.

Observed twice the altitude.	Chron. 1683. Washington mean time.	Remarks.
° ′ ″	h. m. s.	
Sun's lower limb..... 45 50 00	3 48 59.0	Weather cloudy; no shade glasses or cover for artificial horizon used.
45 40 00	3 49 27.0	
45 30 00	3 49 57.5	
45 20 00	3 50 25.0	
Sun's upper limb..... 45 50 00	3 52 09.0	
45 40 00	3 52 39.0	
45 30 00	3 53 09.5	
45 20 00	3 53 39.5	

ELLIS, *Observer.*

SET III.

Observed twice the altitude.	Chron. 1683. Washington mean time.	Remarks.
° ′ ″	h. m. s.	
Sun's lower limb..... 43 40 00	3 55 22.5	Weather cloudy; no shade glasses or cover for artificial horizon used.
43 30 00	3 55 57.5	
43 20 00	3 56 29.5	
43 10 00	3 57 00.5	
43 00 00	3 57 38.0	
Sun's upper limb..... 43 40 00	3 58 40.5	
43 30 00	3 59 12.0	
43 20 00	3 59 40.0	
43 10 00	3 00 09.0	
43 00 00	4 00 43.0	

Index correction, —01′ 00″, found by sea horizon.

ELLIS, *Observer.*

The reduction of these observations gives the following corrections for chronometer 1683 (Washington mean time):

Set I	— 1m 34s.9
Set II	— 1 35.0
Set III	— 1 32.3
Mean	— 1 34.1

By the time-ball at New York, June 13, 1883, the correction to chronometer 1683 was —1m 32s.5. This gives a daily rate to 1683, between New York and Saint John's, of 0s. aining.

Allowing for the rate of 1683, by comparison the following corrections were found on June 26:

Mean-time chronometer 1683	— 1 34.2	Washington mean time.
Mean-time chronometer 1691	— 3 31.6	Do.
Sidereal-time chronometer 1692	— 7 03.1	Washington sidereal time.
Sidereal-time chronometer 1693	— 4 32.6	Do.

On the morning of June 27, chronometer 1683 was taken to the telegraph office and a signal was received by cable from Greenwich at mean noon. This signal gave a correction to 1683 of —1m 30s.6 Washington mean time, but the record comparisons, made before and after, and all subsequent comparisons, have been lost.

SAINT JOHN'S, NEWFOUNDLAND, *June* 28.

The magnetometer and dip-circle were mounted a little west of the intersection of the two walks in an old cemetery on Church Hill in Saint John's. Four sets of observations for dip and two sets of oscillations and deflections for horizontal intensity were taken. Time being limited the declination was not determined. Light rain during night. 3 p. m. observation not taken; observers were on magnetic work.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	47 34	52 41	29.941	.....	58.5	57.5	57	96	0	Calm.
7 a. m.	47 34	52 41	29.987	.....	58	57.5	57	96	N.	Light.
11 a. m.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3 p. m.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7 p. m.	47 34	52 41	29.954	.....	52	50.8	49.6	92	0	Calm.
11 p. m.	47 34	52 41	29.921	.....	51.5	50	48.5	90	N.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.	Hidden.	.....	.....	10	Strat...	0	.....	Cloudy	Lamar.
7 a. m.	Hidden.	.....	.....e...	10	Strat...	N.	.....	Cloudy	Lamar.
11 a. m.	.....	.....	.....	.....	.....	.....	.....	.....	
3 p. m.	.....	.....	.....	.....	.....	.....	.....	.....	
7 p. m.	Hidden.	.....	.....	10	Cu.-st..	0	.....	Cloudy	Ellis.
11 p. m.	0	0	0	0	0	0	....	Clear	Ellis.

Maximum: 65.1 at 3 and 11 p. m. Minimum: 54.0 at 7 a. m. and 11 p. m.

JUNE 29.

Morning was spent in making final preparations for sea, and the instrument shelters were lashed firmly to the deck.

At 4 p. m. the Proteus passed out of harbor, and set course to northward.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometers.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	47 34	52 41	29.754	.....	50	49	48	93	0	Calm.
7 a. m.	47 84	52 41	29.714	.....	69.2	65	62	78	W.	Fresh.
11 a. m.	47 34	52 41	29.628	.....	79	71	66	65	W.	Fresh.
3 p. m.	47 34	52 41	29.577	.....	72	65	60	66	W.	Light.
7 p. m.	48 00	52 40	29.523	.....	54	52	50	86	W.	Light.
11 p. m.	48 33	52 35	29.494	.....	48	48	48	100	W.	Brisk.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.	2	Ci.-cu..	W.	0	0	0	.....	Clear.....	Ellis.
7 a. m.	3	Cirrus .	W.	0	0	0	.....	Clear.....	Ellis.
11 a. m.	2	Ci.-cu..	0	0	0	0	.....	Clear.....	Lamar.
3 p. m.	6	Ci.-cu..	0	0	0	0	.....	Fair.....	Lamar.
7 p. m.	0	0	0	2	Strat...	0	.49	Clear.....	Lamar.
11 p. m.	0	0	0	.....	Lt. fog .	0	49	Clear.....	Lamar.

Maximum: 81°.5 at 3 and 11 p. m. Minimum: 56°.5 at 7 a. m. and 45 at 11 p. m.

AT SEA, *June* 30.

Clear and pleasant weather in the morning; cloudy in afternoon. Latitude at noon was N. 50° 14′.

Brilliant aurora observed throughout the night. At 8.20 p. m. pale yellow light was seen in the west (true) in the form of one bright streamer (A) reaching from about ten degrees above the horizon to twenty-five degrees towards zenith. This appearance soon became faint, but reappeared several times before any other light was observed. Finally, from a point W. by S. in the horizon, a pale yellow light was observed to enlarge very rapidly, and in a very few seconds it appeared as the tail of a vast comet (B), curving to the southward as it rose to the altitude of 65°. B faded from view in two or three minutes and then a bow (C) was seen at 8.30, extending from NE. (true) round to the west. The altitude of this bow was about 40°; its light was a brighter yellow than B, and a decided tinge of green was observed. At 8.35 p. m. cirrus and thin cirro-cumulus clouds obscured the heavens almost instantaneously. These clouds were, for a few seconds, tinted with the auroral light, and then all was darkness. At 9.28 p. m. B was again seen rising by pulsations, increasing in brilliancy every moment, and at 9.34 p. m. the northeastern half of arch (C) was observed. The other part could not be seen, but this half arch remained for two minutes, and then faded away. Its light was not so bright as when the bow was complete, nor could the greenish tinge be observed. At 9.40 p. m., from a point E. by S. in the horizon, an appearance like a comet's tail (D), similar to B, rose with the same curve to the southward, and in a few seconds B and D, with one simultaneous pulsation, extended and joined each other in the south (true) and formed one magnificent pale yellow arch (E). Altitude about 70° and the arch nearly perpendicular to the astronomical meridian. It remained in all its splendor for several minutes. No streamers could be seen; it was simply a regular band of pale yellow light; no greenish tinge (*or noise*). At 9.48 p. m. E was observed to be moving northward and was soon in the zenith with its ends in the eastern and western points of the horizon. But, as the arch moved northward, the band became wider and the light more diffused. The entire bow (C) again became visible, and, as E approached, long streamers rose from it to the zenith from every point of the arch, forming a corona. The streamers from C became brighter and larger as E approached, and they finally diffused so much light and so penetrated E that it could no longer be distinguished in the magnificent corona.

At 10 p. m. the streamers ceased and C soon died away. A very remarkable phenomenon was then observed. Occupying the position of E before it began to move northward was a dark bow (F). When first observed it was thought to be a bow of clouds, but the stars could be seen *shining* through the dark band with unusual brightness, and, upon careful examination, the band seemed to be of an irregular fibrous structure, the fiber being cirrus clouds faintly colored with the auroral light. The small proportion of these cirrus clouds gave a contrast which made the band appear very dark. F remained stationary in this position about as long as E had done and then it began to expand and move to the northward in the same manner as E, but the lower or southern extremity remained stationary, while the fibrous cirrus and the dark segments enlarged rapidly and arranged themselves into seven alternate, irregular, dark and light bands. This process of expansion continued till the foremost band had moved northward through the zenith to the point where E was last seen. At 10.45 p. m. the arches faded from view. C again became visible at 10.47 p. m., and streamers from the arch rose to zenith. At 10.52 p. m. no auroral light could be seen, except in the eastern and western points of the horizon. At 10.53 p. m. western half of C again became visible, but soon faded and cirro-cumulus clouds almost instantly covered the entire heavens. Nothing more was seen of the aurora during the night.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometers.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	49 06	52 31	29.481	.....	59	58.5	58	96	W.	Light.
7 a. m.	49.38	52.28	29.497	.....	56.2	54	51.8	82	NW.	Light.
11 a. m.	50 12	52 22	29.487	.....	54.5	52.3	49.9	84	NW.	Light.
3 p. m.	50 43	52 22	29.528	.....	47.1	45.1	43.1	86	N.	Fresh.
7 p. m.	51 14	52 26	29.615	.....	43	42	41	93	NE.	Fresh.
11 p. m.	51 47	52 27	29.623	.....	41.2	40.7	40.2	96	N.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.	2	Ci.-st.	0	4	Strat.	0	.....	Fair	Lamar.
7 a. m.	2	Ci.-cu.	NW.	0	0	0	46	Clear	Ellis.
11 a. m.	3	Ci.-cu.	NW.	0	0	0	45	Clear	Ellis.
3 p. m.	Hidden.	.....	.....	10	Cu.-st.	N.	43.5	Cloudy	Ellis.
7 p. m.	Hidden.	.....	.....	10	Cu.-st.	NE.	42	Cloudy	Ellis.
11 p. m.	4	Ci.-cu.	NE.	0	0	0	40.5	Fair	Ellis.

Maximum: 63.1 at 3 and 11 p. m. Minimum: 46.8 at 7 a. m., and 40.0 at 11 p. m.

JULY 1.

Large masses of ice passed throughout the day. Longitude, from morning observations, W. 53° 04′. Clouds at noon prevented observation for latitude. Sun set at 7 p. m., Washington time. At 9.50 p. m. the vessel commenced to push her way through ice. At 11.30 p. m. dense fog settled down over the water and the vessel stopped steaming. Rain began and ended during night.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometers.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	52 19	52 31	29.665	.....	40	39.8	39.4	98	NE.	Light.
7 a. m.	52 53	52 33	29.653	.....	41	40	39	92	NE.	Light.
11 a. m.	53 24	52 36	29.637	.....	41	40	39	92	NE.	Light.
3 p. m.	53 57	52 37	29.633	.....	39	38.5	37.5	94	NE.	Light.
7 p. m.	54 25	52 32	29.626	.....	39.8	37.3	33.5	78	NE.	Light.
11 p. m.	54 52	52 30	29.605	.....	35	35	35	100	NE.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.	Hidden.	.....	.....	10	Strat.	0	38.8	Cloudy	Ellis.
7 a. m.	Hidden.	.....	.....	10	Strat.	0	37	Cloudy	Lamar.
11 a. m.	Hidden	.....	.....	10	Strat.	0	37	Cloudy	Lamar.
3 p. m.	Hidden.	.....	.....	10	Strat.	0	38	Cloudy	Lamar.
7 p. m.	0	0	0	8	Cu.-st.	0	35	Cloudy	Lamar.
11 p. m.	Hidden.	.....	.....	Dense.	Fog.	.....	33	Foggy	Lamar.

Maximum: 41.0 at 3 and 11 p. m. Minimum: 38.0 at 7 a. m., and 33.0 at 11 p. m.

JULY 2.

At 4.30 a. m., fog clearing away, the vessel steamed ahead. The ice soon disappeared, and no more was seen throughout the day. Temperature of the water rose from 33°, at 3 a. m., to 43°.2, at 11 a. m. Clouds in the afternoon were a perfect

type of the cirrus and cirro-stratus. Longitude, from morning observations, W. 52° 30′. Latitude, from meridian altitude at noon, N. 55° 24′. Longitude, by afternoon observations, W. 51° 57′.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.....	54 56	52 27	29.544	.....	33.5	33.5	33.5	100	E.	Light.
7 a. m.....	55 04	52 27	29.541	.....	39.1	36.5	32.3	77	N.	Light.
11 a. m.....	55 15	52 27	29.530	.....	47.7	44.0	39.1	72	N.	Light.
2 p. m.....	.....	.....	.....	.....	49.1	.....	.....	.....	.....	.....
3 p. m	55 46	52 20	29.528	.....	46.8	44.4	41.0	81	N.	Light.
7 p. m.....	56 22	52 05	29.531	.....	41.2	41.0	40.8	98	E.	Light.
11 p. m.....	56 56	51 58	29.505	.....	40.0	39.4	38.2	93	E.	Fresh.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.....	Hidden.	.....	.....	Dense..	Fog	.....	.....	Foggy	Lamar.
7 a. m.....	0	0	0	Light ..	Haze ...	.....	33.2	Clear	Ellis.
11 a. m.....	0	0	0	Dense..	Haze ...	.....	43.2	Hazy	Ellis.
2 p. m.....	.....	.....	.....	.....	.....	.....	42.2	.....	
3 p. m.....	3	Cir.....	0	0	0	0	41.1	Clear	Ellis.
7 p. m.....	4	Ci.-st ..	0	0	0	0	41.1	Fair	Ellis.
11 p. m.....	Hidden.	.....	.....	10	St	0	40.5	Cloudy.....	Ellis.

Maximum: 52.2 at 3 p. m.; 52.4 at 11 p. m. Minimum: 31.1 at 7 a. m.; 29.5 at 11 p. m.

JULY 3.

Stormy weather and rough sea. Rain began at 5 a. m. and ended at 10 p. m. No observations for latitude or longitude were made on account of the foul weather. Twilight at midnight showed that we were nearing the land of the midnight sun.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.....	57 31	51 49	29.421	.....	40.5	40.4	40.2	99	E.	Fresh.
7 a. m.....	58 04	51 40	29.382	.....	41.0	41.0	41.0	100	SW.	Brisk.
11 a. m.....	58 38	51 30	29.211	.....	40.5	40.5	40.5	100	SW.	Brisk.
2 p. m.....	.....	.....	.....	.....	41.0	.....	.....	.....	.....	.....
3 p. m.....	59 15	51 32	29.135	.....	41.5	41.5	41.5	100	S.	Brisk.
7 p. m	59 45	51 38	29.111	.....	40.0	40.0	40.0	100	SE.	Brisk.
11 p. m.....	60 18	51 48	29.224	.....	39.0	39.0	39.0	100	SE.	Fresh.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.....	Hidden.	.....	.....	10	Strat...	0	40.7	Cloudy.....	Ellis.
7 a. m.....	Hidden.	.....	.....	10	Nim....	0	40.0	Light rain..	Lamar.
11 a. m.....	Hidden.	.....	.....	10	Nim....	0	41.0	Light rain..	Lamar.
2 p. m.....	.....	.....	.....	.....	.....	0	41.0	.....	
3 p. m.....	Hidden.	.....	.....	10	Nim....		41.0	Light rain..	Lamar.
7 p. m.....	Hidden.	.....	.....	10	Nim....	0	39.5	Light rain..	Lamar.
11 p. m.....	Hidden.	.....	.....	10	St	0	39.0	Cloudy.....	Lamar.

Maximum: 41.5 at 3 and 11 p. m. Minimum: 38.5 at 7 a. m. and 11 p. m.

JULY 4.

Sky covered with heavy stratus clouds. Several icebergs were seen in the morning. At 2 p. m. passed a solitary iceberg, and at 4 p. m. passed them frequently. Very cloudy at noon, but determined the latitude to be 62° 07′ N. Sea washed over the rain-gauge several times, thus making it impossible to measure the amount of rainfall Thermometers in shelters were wet several times. Rain began at 10 a. m. and ended at 2 p. m. Rain began again at 10.15 p. m. and ended at 10.45 p. m.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	60 54	51 55	29.333	.....	39	39	39	100	SW.	Fresh.
7 a. m.	61 26	52 01	29.426	.....	41.2	39.5	37.1	86	SE.	Light.
11 a. m.	61 59	52 06	29.532	.....	39.8	39.3	38.3	94	SE.	Light.
2 p. m.	.....	.....	.....	.....	40.8	.....	.....	.....	.....	.....
3 p. m.	62 27	52 22	29.575	.....	40.3	39.7	38.7	94	S.	Light.
7 p. m.	62 57	52 41	29.605	.....	36.2	36.2	36.2	100	S.	Fresh.
11 p. m.	63 30	53 00	29.650	.....	36.2	36.2	36.2	100	S.	Fresh.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.	Hidden.	.....	.....	10	St	0	39.0	Cloudy	Lamar.
7 a. m.	Hidden.	.....	.....	10	St	0	39.0	Cloudy	Ellis.
11 a. m.	Hidden.	.....	.....	10	Nim ...	0	39.0	Light rain .	Ellis.
2 p. m.	.....	.....	.....	.....	Lt. fog .	0	35.3	.....	
3 p. m.	Hidden.	.....	.....	10	St.	0	37.5	Cloudy	Ellis.
7 p. m.	Hidden.	.....	.....	10	St.	0	33.5	Cloudy	Ellis.
11 p. m.	Hidden.	.....	.....	10	St.	0	34.8	Cloudy	Ellis.

Maximum: 45.1 at 3 and 11 p. m. Minimum: 36.1 at 7 a. m. and 11 p. m.

JULY 5.

Cloudy in morning; clear and pleasant during afternoon.

The Greenland coast was sighted about noon. Large quantities of sea-weed were noticed in the water several hours before land was seen. Passing icebergs during the entire day. Ran into dense fog at 6.30 p. m., and the vessel steamed very slowly until 7.25 p. m., when the fog lifted.

The sun reached its lower culmination at 10.10 p. m., and a sight was taken with sextant for latitude, which gave 67° 25′ N.; this result is a little uncertain on account of great refraction at such low altitude.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	64 02	53 22	29.701	.....	36.8	36.8	36.8	100	SE.	Fresh.
7 a. m.	64 34	53 40	29.678	.....	38	37.5	36.5	94	SE.	Light.
11 a. m.	65 03	54 00	29.724	.....	39	38.5	37.5	94	SE.	Light.
2 p. m.	.....	.....	.....	.....	42	.....	.....	.....	.....	.....
3 p. m.	65 38	54 21	29.744	.....	42	41	40	92	SE.	Light.
7 p. m.	66 14	54 22	29.652	.....	35	35	35	100	SE.	Light.
11 p. m.	66 47	54 30	29.712	.....	37	36.5	35.5	94	SE.	Fresh.

T Sinclair & Son. lith. Phila.

DISCO ISLAND, GREENLAND (GODHAVN)

PHOTOGRAPHED FROM A SKETCH BY H.C. DRESEL

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m	Hidden.	.....	.....	10	St. ...	0	35.7	Cloudy	Ellis.
7 a. m	Hidden	.....	.....	10	St.	0	35.3	Cloudy	Lamar.
11 a. m	Hidden.	.....	.....	10	St.	0	37.5	Cloudy	Lamar.
2 p. m	.....	.....	.....	.....	.....	.....	37.0	.....	.....
3 p. m	2	Cir ...	0	0	0	0	37.0	Clear	Lamar.
7 p. m	Hidden.	.....	.....	.....	Dense..	Fog...	36.0	Foggy	Lamar.
11 p. m	0	0	0	2	St.	0	35.5	Clear	Lamar.

Maximum: 43.0 at 3 and 11 p. m. Minimum: 34.0 at 7 a. m.; 33.0 at 11 p. m.

JULY 6.

All day passed in sight of the Greenland coast. Latitude, at noon, 68° 29′. No time sights were taken in the morning, on account of having no horizon, the sun being over the coast. At 3.30 p. m., while on the lookout for Godhavn, a small boat was sighted to the westward. The boat was found to contain several of the inhabitants of Godhavn. The vessel had missed the harbor, and had passed two or three miles to the eastward. Anchored in the harbor of Godhavn at 5.40 p. m. Weather cloudy in the morning, clearing in the afternoon. Very little wind.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m	67 17	54 40	29.718	.....	37.9	37.1	35.5	91	N.	Fresh.
7 a. m	67 48	54 41	29.707	.....	38.8	37.5	35.2	90	N.	Fresh.
11 a. m	68 20	54 25	29.799	.....	45.2	42.2	38.2	76	0	Calm.
2 p. m	.....	.....	.....	.....	44.8	.....	.....	.....	.....	.....
3 p. m	68 50	54 13	29.877	.....	42.2	41.0	39.6	90	0	Calm.
7 p. m	69 14	53 24	29.861	.....	42.1	41.1	40.1	92	NE.	Gentle.
11 p. m	69 14	53 24	29.759	.....	47.0	42.8	36.6	67	0	Calm.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m	Hidden.	.....	.....	10	Strat...	0	33.7	Cloudy.....	Ellis.
7 a. m	Hidden	.....	.....	10	Strat...	0	34.5	Cloudy.....	Ellis.
11 a. m	0	0	0	8	Cum ...	0	36.1	Cloudy.....	Ellis.
2 p. m	.....	.....	.....	.....	.....	.....	39.3	.....	.....
3 p. m	0	0	0	1	Cum ...	0	38.6	Clear	Ellis.
7 p. m	0	0	0	1	Cu.-st..	0	41.1	Clear	Ellis.
11 p. m	6	Ci.-st...	SE.	0	0	0	39.8	.....	Ellis.

Maximum: 51.2 at 3 and 11 p. m. Minimum: 35.5 at 7 a. m; 34.1 at 11 p. m.

GODHAVN, GREENLAND, *July* 7.

At 10 a. m. ship started for Egedesmind, a Danish settlement, about 30 miles south of Godhavn. Numerous icebergs were passed. Returned to Godhavn about midnight.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.....	69 14	53 24	29.783	.....	46.2	42.8	38.0	73	NE.	Fresh
7 a. m.....	69 14	53 24	29.808	.....	50.0	45.0	38.0	64	S.	Fresh.
11 a. m.....	69 10	53 50	29.756	.....	47.0	45.0	43.0	86	SW.	Fresh.
2 p. m	.....	.....	.....	.....	49.0	.....	.....	.....	.....	.....
3 p. m.....	68 57	53 30	29.753	.....	49.0	45.0	40.0	71	S.	Light.
7 p. m.....	68 43	53 30	29.717	.....	44.0	42.0	39.0	83	SE.	Light.
11 p. m	69 08	53 50	29.673	.....	42.0	41.0	40.0	92	N.	Fresh.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.....	Hidden	.....	.....	10	Strat...	NE.	38.0	Cloudy.....	Ellis.
7 a. m.....	Hidden	.....	.....	10	Strat...	S.	38.5	Cloudy.....	Lamar.
11 a. m.....	0	0	0	8	Cu.-st..	0	40.5	Cloudy.....	Lamar.
2 p. m.....	.....	.....	.....	.....	.....	.....	34.3	.....	.....
3 p. m.....	6	Cir....	S.	0	0	0	34.5	Fair	Lamar.
7 p. m.....	3	Cir.....	0	0	0	0	34.0	Clear	Lamar.
11 p. m.....	0	0	0	3	Strat...	0	39.8	Clear	Lamar.

Maximum: 54.5 at 3 and 11 p. m. Minimum: 45.0 at 7 a. m; 39.0 at 11 p. m.

GODHAVN, GREENLAND, *July* 8.

Magnetic instruments were taken ashore and set up near the center of the village, sufficiently removed from disturbing influences. Three sets of dip, and two sets with the Lloyd needle,* and two sets of oscillations and deflections for horizontal intensity were secured. Mosquitoes very annoying; were very numerous and of unusual size. The 3 p. m. observation was not taken, observers being away on magnetic work.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.....	69 14	53 24	29.724	.....	49.0	45.0	40.0	71	NE.	Light.
7 a. m.....	69 14	53 24	29.766	.....	48.5	45.4	41.3	76	N.	Gentle.
11 a. m.....	69 14	53 24	29.797	.....	49.0	46.0	42.0	77	N.	Gentle.
3 p. m.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7 p. m.....	69 14	53 24	29.810	.....	56.5	49.0	40.0	55	SE.	Light.
11 p. m.....	69 14	53 24	29.664	.....	44.3	43.2	42.0	92	0	Calm.

* Lost with the Proteus.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.	0	0	0	0	0	0	39.5	Clear	Lamar.
7 a. m.	0	0	0	0	0	0	39.1	Clear	Ellis.
11 a. m.	0	0	0	8	Cum	0	39.2	Cloudy	Lamar.
3 p. m.									
7 p. m.	8	Ci. st	S.	0	0	0	39.0	Cloudy	Lamar.
11 p. m.	8	Cir	0	0	0	0	39.2	Clear	Ellis.

Maximum: 57.6 at 3 and 11 p. m. Minimum: 41.1 at 7 a. m.; 40.7 at 11 p. m.

GODHAVN, GREENLAND, *July* 9.

Magnetic observations continued. Two sets of dip and one set with the Lloyd* needle, four sets of azimuth and one latitude observation were taken. Suspended magnet and commenced observations for declination at 4 p. m. The latitude observation was taken with large theodolite, reversing it three times, measuring one altitude before noon, one about noon, and one a little after. The theodolite was in almost perfect adjustment. Latitude N. 69° 13′ 55″.4.

LAMAR, *Observer*.

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	69 14	53 24	29.785		46.8	44.0	40.4	79	NE.	Light.
7 a. m.	69 14	53 24	29.726		56.5	49.0	40.0	54	NE.	Light.
11 a. m.	69 14	53 24	29.730		57.0	51.0	45.0	64	S.	Fresh.
2 p. m.					57.5					
3 p. m.	69 14	53 24	29.699		58.0	52.0	46.0	64	S.	Fresh.
7 p. m.	69 14	53 24	29.717		56.0	51.0	46.0	69	S.	Fresh.
11 p. m.	69 14	53 24	29.747		50.5	46.7	42.0	73	NE.	Fresh.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.	2	Cir	NE.	0	0	0	40.0	Clear	Ellis.
7 a. m.	3	Cir	N.	0	0	0	40.1	Clear	Lamar.
11 a. m.	3	Cir	SE.	0	0	0	40.4	Clear	Lamar.
2 p. m.									
3 p. m.	3	Cir	0	0	0	0	40.4	Clear	Lamar.
7 p. m.	5	Ci.-cir	S.	0	0	0	40.6	Fair	Lamar.
11 p. m.	3	Cir	NE.	0	0	0	42.0	Clear	Ellis.

Maximum: 60.0 at 3 p. m.; 61.6 at 11 p. m. Minimum: 40.5 at 7 a. m.; 38.8 at 11 p. m.

*Notes of observations with Lloyd needle and azimuth and altitude observations were lost with the Proteus.

GODHAVN, GREENLAND, *July* 10.

Magnetic observations continued for declination. Two sets of oscillations and deflections for horizontal intensity were taken. Three sets of lunar distances were secured.* Weather clear and very warm. At 7 a. m. water temperature in harbor, at the depth of 25 feet, was 40°.4. The 3 p. m. observation was not taken, observers being on shore making magnetic observations.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.										
7 a. m.	69 14	53 24	29.857	.....	51.6	48.1	44.1	76	E.	Gentle.
11 a. m.	69 14	53 24	29.867	.....	56.0	54.0	52.0	86	SW.	Light.
2 p. m.					58.5					
3 p. m.	69 14	53 24	29.852	.....	58.7	55.0	51.3	77	E.	Gentle.
7 p. m.										
11 p. m.	69 14	53 24	29.898	.....	50.0	49.5	49.0	96	NE.	Gentle.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.									
7 a. m.	0	0	0	0	0	0	43.5	Clear	Ellis.
11 a. m.	1	Cir	0	0	0	0	44.0	Clear	Lamar.
2 p. m.							43.4		
3 p. m.	1	Cir	E.	0	0	0	43.5	Clear	Ellis.
7 p. m.									
11 p. m.	6	Ci. st..	NE.	0	0	0	44.7	Fair	Ellis.

Maximum: 67.0 at 3 and 11 p. m. Minimum: 47.0 at 7 a. m.; 46.0 at 11 p. m.

GODHAVN, GREENLAND, *July* 11.

Day was spent computing the magnetic and other observations which had been previously made on shore.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.										
7 a. m.	69 14	53 24	29.986	.....	52.2	52.0	51.8	98	E.	Fresh.
11 a. m.	69 14	53 24	30.011	.....	54.0	50.0	46.0	74	SW.	Light.
2 p. m.					55.0					
3 p. m.	69 14	53 24	30.004	.....	55.0	50.0	45.0	69	SE.	Light.
7 p. m.	69 14	53 24	30.058	.....	53.4	49.9	45.9	76	0	Calm.
11 p. m.	69 14	30 24	53.088	.....	51.0	48.0	45.1	80	NW.	Light.

* Lost with the Proteus.

Washington time.	Clouds. Upper. Amount.	Kind.	Direction.	Lower. Amount.	Kind.	Direction.	Water temperature.	State of weather.	Observer.
							°		
8 a. m.									
7 a. m.	1	Cir.	E.	0	0	0	43.5	Clear	Ellis.
11 a. m.	0	0	0	0	0	0	44.5	Clear	Lamar.
2 p. m.							44.5		
3 p. m.	0	0	0	0	0	0	44.5	Clear	Lamar.
7 p. m.	2	Cl. st.	NE.	0	0	0	46.0	Clear	Ellis.
11 p. m.	3	Cl. cu.	N.	0	0	0	44.8	Clear	Lamar.

Maximum: 67.5 at 3 and 11 p. m. Minimum: 46.1 at 7 a. m. and 11 p. m.

GODHAVN, GREENLAND, *July* 12.

Comparative reading of barometers on board the ship were made.

COMPARISONS.

Time.	Attached thermometer.	Barometer No. 530.	Attached thermometer.	Barometer No. 531.	Thermometer.	Aneroid No. 1926.	Thermometer.	Aneroid 4530.	Thermometer.	Ship's aneroid.	Observer.
	°		°		°		°		°		
7 p. m.	62	29.884	63	20.896	63	29.820	63	29.830	62	30.160	Lamar.
		−.090		−.093							
		+.001		−.001							
		29.798		29.802							
8 p. m.	61	29.890	63	29.896	63	29.880	62	29.890	61	30.155	Lamar.
		−.087		−.090							
		+.001		−.001							
		29.802		29.805							
9 p. m.	59	29.904	61	29.914	61	29.890	61	29.850	59	30.165	Lamar.
		−.082		−.087							
		+.001		−.001							
		29.831		29.826							
10 p. m.	58	29.900	62	29.912	63	29.900	62	29.855	58	30.170	Lamar.
		−.079		−.090							
		+.001		−.001							
		29.820		29.821							

Barometers 530 and 531 show an average difference of .004.

Washington time.	Position. Latitude.	Longitude.	Barometer. Actual.	Reduced.	Thermometer. Dry bulb.	Wet bulb.	Dew-point.	Relative humidity.	Wind. Direction.	Velocity
	° ′	° ′			°	°	°			
8 a. m.	69 14	53 24	30.063		53	50	47	80	S.	Light.
7 a. m.	69 14	53 24	30.002		54	50	46	74	S.	Light.
11 a. m.	69 14	53 24	29.890		55.5	50.5	45.5	69	S.	Fresh.
2 p. m.					58					
8 p. m.	69 14	53 24	29.830		54.8	50	45	70	E.	Gentle.
7 p. m.	69 14	53 24	29.850		52.2	48	42.8	71	E.	Gentle.
11 p. m.	69 14	53 24	29.848		51.7	47.7	42.7	72	SW.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.....	0	0	0	0	0	0	44.6	Clear	Lamar.
7 a. m.....	0	0	0	0	0	0	44.5	Clear	Lamar.
11 a. m.....	0	0	0	0	0	0	44.5	Clear	Lamar.
2 p. m.....	.....	.....	.....	.....	.....	.....	45.5	.....	.....
3 p. m.....	2	Cir.....	E.	0	0	0	43.8	Clear	Ellis.
7 p. m.....	2	Cir.....	E.	0	0	0	45.3	Clear	Ellis.
11 p. m.....	7	Ci.-st ..	0	0	0	0	44.3	Fair	Ellis.

Maximum: 58.0 at 3 and 11 p. m. Minimum: 45.5 at 7 a. m. and 11 p. m.

GODHAVN, GREENLAND, *July* 13.

Mean time box-chronometer 1691 was compared with the standard chronometer of the Yantic by means of pocket-chronometer 5695. The comparison showed a discrepancy of 7.8 seconds, No. 1691 being slow on the standard of the Yantic. Theodolite was taken ashore for additional azimuth observations, but clouds obscured the sun before instrument could be set up. Temperature of water in harbor at the depth of 25 feet at 2 p. m., was 44 degrees. Rain began at 3.30 a. m. and ended at 9 a. m. Rain began again at 2.40 p. m. and continued during the remainder of the day.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°				
3 a. m.....	69 14	53 24	29.914	.....	47	46.5	46	96	N.	Light.
7 a. m.....	69 14	53 24	29.991	.....	47	47	47	100	N.	Light.
11 a. m.....	69 14	53 24	29.968	.....	42	42	42	100	E.	Light.
2 p. m.....	.....	.....	.....	.....	47.6	.....	.....	.....	.....	.....
3 p. m.....	69 14	53 24	29.728	.....	43	43	43	100	N.	Light.
7 p. m.....	69 14	53 24	29.760	.....	46	46	46	100	NE.	Light.
11 p. m.....	69 14	53 24	29.696	.....	46	46	46	100	SW.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.....	Hidden	.....	.....	10	Strat ..	0	44	Cloudy	Ellis.
7 a. m.....	Hidden	.....	.....	10	Nim ...	N.	44	Light rain .	Lamar.
11 a. m.....	Hidden	.....	.....	10	Strat ..	0	44	Cloudy	Ellis.
2 p. m.....	.....	.....	.....	.....	.....	.....	44.1	.....	.....
3 p. m.....	Hidden	.....	.....	10	Nim ...	0	44.1	Light rain .	Lamar.
7 p. m.....	Hidden	.....	.....	10	Nim ...	0	44.5	Light rain .	Lamar.
11 p. m.....	Hidden	.....	.....	10	Nim ...	0	44.5	Light rain .	Lamar.

Maximum: 53.2 at 3 p. m.; 54.5 at 11 p. m. Minimum: 41.5 at 7 a. m. and 11 p. m.

GODHAVN, GREENLAND, *July* 14.

Rain ended at 10 a. m., but began again at 1 p. m. and continued during the remainder of the day. Day was spent in revising time and azimuth computations.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity
	° ′	° ′			°	°	°			
3 a. m.										
7 a. m.	69 14	53 24	29.769		38.8	38.8	38.8	100	S.	Fresh.
11 a. m.	69 14	53 24	29.943		38	38	38	100	SE.	Fresh.
2 p. m.					38.7					
3 p. m.	69 14	53 24	30.018		38	38	38	100	SE.	Gentle.
7 p. m.	69 14	53 24	30.016		39	39	39	100	SE.	Light.
11 p. m.	69 14	53 24	30.016		39	39	39	100	0	Calm.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.									
7 a. m.	Hidden.			10	Nim.	0	43	Light rain.	Ellis.
11 a. m.	Hidden.			10	Strat.	0	42.6	Cloudy.	Ellis.
2 p. m.							42.7		
3 p. m.	Hidden			10	Nim.	0	42.8	Light rain.	Ellis.
7 p. m.	Hidden.			10	Nim.	0	42.5	Light rain.	Ellis.
11 p. m.	Hidden			10	Nim.	0	42.2	Light rain.	Ellis.

Maximum: 48.0 at 3 p. m.; 48.2 at 11 p. m. Minimum: 37.7 at 7 a. m.; 34.9 at 11 p. m.

GODHAVN, GREENLAND, *July* 15.

The clouds, which had covered the high hills north of the harbor since the 14th, cleared away with a change of wind, leaving the hills covered with fresh snow, though the temperature at the vessel had not been below 34°.9.

Rain continued all day. Rainfall from 11 p. m. of 14th to 11 p. m. of 15th was 2.67 inches.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	69 14	53 24	30.022		38	38	38	100	0	Calm.
7 a. m.	69 14	53 24	29.976		41	41	41	100	NE.	Light.
1 a. m.	69 14	53 24	29.968		42	42	42	100	S.	Light.
2 p. m.					42					
3 p. m.	69 14	53 24	29.945		42	42	42	100	SW.	Light.
7 p. m.	69 14	53 24	29.938		40	40	40	100	SE.	Light.
11 p. m.	69 14	53 24	29.946		38	38	38	100	S.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
8 a. m	Hidden			10	Nim	0	42.1	Light rain	Ellis.
7 a. m	Hidden			10	Nim	0	42	Light rain	Lamar.
11 a. m	Hidden			10	Nim	0	42	Light rain	Ellis.
2 p. m							42.5		
3 p. m	Hidden			10	Nim	0	42.6	Light rain	Lamar.
7 p. m	Hidden			10	Nim	0	41.8	Light rain	Lamar.
11 p. m	Hidden			10	Nim	0	41.0	Light rain	Lamar.

Maximum: 44.6 at 3 p. m., 45.0 at 11 p. m. Minimum: 36.0 at 7 a. m., 35.8 at 11 p. m.

JULY 16.

Rain ended at 1 a. m. Left Godhavn harbor at 4 a. m. Weather foggy until 3 p. m., when fog cleared away and not a cloud was to be seen. The vessel stopped at Disco Fjord from 8 a. m. until 2.20 p. m. Passed along parallel to the Greenland coast. Latitude, from observation on the sun at its lower culmination, 70° 10′.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
8 a. m	69 14	53 24	29.978		38	38	38	100	S.	Light.
7 a. m	69 23	54 23	30.006		38.8	38.8	38.8	100	0	Calm.
11 a. m	69 24	54 38	30.024		40.9	40.9	40.9	100	0	Calm.
2 p. m					39.8					
3 p. m	69 26	54 44	29.915		39.1	39.1	39.1	100	0	Calm.
7 p. m	69 53	55 31	29.992		39	38.5	37.5	94	N.	Light.
11 p. m	70 21	55 59	29.963		37	36.5	35.5	94	N.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
8 a. m	Hidden			10	Strat	0	41	Cloudy	Lamar.
7 a. m	Hidden			Dense	Fog		40.4	Foggy	Ellis.
11 a. m	Hidden			Dense	Fog		41.5	Foggy	Ellis.
2 p. m							41.8		
3 p. m	Hidden			Dense	Fog		41.9	Foggy	Ellis.
7 p. m	0	0	0	0	0	0	38	Clear	Lamar.
11 p. m	0	0	0	0	0	0	36.5	Clear	Lamar.

Maximum: 49.2 at 3 and 11 p. m. Minimum: 35.0 at 7 a. m.; 33.5 at 11 p. m.

JULY 17.

Light northerly winds. Icebergs becoming more numerous. Smooth sea. Noon observation gave latitude 71° 43′. Observation in the afternoon gave longitude W. 58° 06′. The coast was about 40 miles distant, but the atmosphere was so clear that it did not seem half so far. Cloudy in the afternoon. Rain began at 10.30 p. m. and ended at 10.35 p. m.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	70 49	56 28	30.001	.....	37.7	36.9	35.3	91	N.	Light.
7 a. m.	71 14	56 55	30.015	.....	42.5	41	39	88	N.	Light.
11 a. m.	71 35	57 20	29.988	.....	45	43	40	83	N.	Light.
3 p. m.	72 03	57 59	29.976	.....	44.5	42.5	39.5	83	N.	Light.
7 p. m.	72 25	58 39	29.954	.....	38.7	37.8	36	90	N.	Light.
11 p. m.	72 48	59 19	29.903	.....	36.6	36.6	36.6	100	W.	Light.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
3 a. m.	0	0	0	1	Cum ...	0	34.4	Clear	Ellis.
7 a. m.	3	Cir.....	0	0	0	0	38.2	Clear	Ellis.
11 a. m.	7	Cir.-cu	0	0	0	0	38.2	Fair	Lamar.
3 p. m.	1	Cir.....	0	2	Strat...	0	37.5	Cloudy	Lamar.
				6	Cum ...	0			
7 p. m.	7	Ci.-st...	0	3	Strat...	0	34.5	Cloudy ...	Ellis.
11 p. m.	Hidden.	.....	.....	8	Strat...	0	38.4	Cloudy	Ellis.
				3	Cu.-st..	W.			

Maximum: 51.1 at 3 and 11 p. m. Minimum: 35.3 at 7 a. m.; 32.3 at 11 p. m.

JULY 18.

At midnight cloudy and very thick. Not as much ice as usual to be seen. At 4 a. m. sighted an ice pack ahead, and in five minutes came up to it. Entered the pack at 5 a. m. Temperature of the water at this time 30°.5, and the same at a depth of twenty-five feet. This ice varied in thickness from six to twenty-four inches. Fragments of icebergs, eight to ten feet in thickness, were scattered through the field-ice. Many seal were seen on the ice and swimming in the water. The sea had the appearance of a prairie covered with snow in patches. Fog settled down over the water at 2 p. m., and the vessel went forward slowly. Fog cleared a little at 2.30 p. m. At noon maximum altitude of sun, measured from horizon of ice, gave latitude 74° 08′. At 4.45 p. m. very light, drizzling rain began.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	73 14	60 00	29.928	.....	35	35	35	100	W.	Light.
7 a. m.	73 37	60 38	29.943	.....	35	35	35	100	N.	Light.
11 a. m.	73 59	61 20	29.945	.....	37	36.3	34.9	92	0	Calm.
3 p. m.	74 18	61 52	29.956	.....	35.2	35.2	35.2	100	0	Calm.
7 p. m.	74 48	62 20	29.950	.....	33	33	33	100	NE.	Light.
11 p. m.	74 57	62 47	29.929	.....	33	33	33	100	0	Calm.

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PROTEUS STOPPED BY THE ICE AT THE HEAD OF MELVILLE BAY, JULY 19TH

AVOIDING A NIP NEAR CONICAL ROCK, AUG. 7TH

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
1 a. m.	.....	.....	.....	.....	.....	.....	31.2	.....	
2 a. m.	.....	.....	.....	.....	.....	.....	31	.....	
3 a. m.	Hidden.	.....	.....	10	Nim ...	0	31	Light rain .	Ellis.
4 a. m.	.....	.....	.....	.....	.....	.....	31.2	.....	
5 a. m.	.....	.....	.....	.....	.....	.....	31.2	.....	
6 a. m.	.....	.....	.....	.....	.....	.....	31.2	.....	
7 a. m.	Hidden.	.....	.....	10	Strat...	0	31.2	Cloudy	Ellis.
8 a. m.	.....	.....	.....	.....	.....	.....	32	.....	
9 a. m.	.....	.....	.....	.....	.....	.....	32.2	.....	
10 a. m.	.....	.....	.....	.....	.....	.....	32.5	.....	
11 a. m.	5	Cir.....	0	0	0	0	33.5	Fair	Lamar.
12 m.	.....	.....	.....	.....	.....	.....	34.5	.....	
1 p. m.	.....	.....	.....	.....	.....	.....	34.5	.....	
2 p. m.	.....	.....	.....	.....	.....	.....	34	.....	
3 p. m.	1	Ci.-st...	0	0	0	0	34.8	Clear	Lamar.
4 p. m.	.....	.....	.....	.....	.....	.....	34.8	.....	
5 p. m.	.....	.....	.....	.....	.....	.....	34.8	.....	
6 p. m.	.....	.....	.....	.....	.....	.....	35	.....	
7 p. m.	4	Ci.-cu ..	0	0	0	0	35	Fair	Ellis.
8 p. m.	.....	.....	.....	.....	.....	.....	34.5	.....	
9 p. m.	.....	.....	.....	.....	.....	.....	34	.....	
10 p. m.	.....	.....	.....	.....	.....	.....	32	.....	
11 p. m.	2	Cir.....	0	0	0	0	31	Clear	Ellis.

Maximum: 45.3 at 3 and 11 p. m. Minimum: 31.9 at 7 a. m.; 30.0 at 11 p. m.

JULY 20.

Ship made as nearly a west course as possible in the ice-pack, being compelled to keep a considerable distance from land on account of heavy ice. A thin film of young ice formed over the open pools of water, though the temperature of the water, at the surface, did not fall below 30°, showing that the water composing the thin film was fresh water from the melting ice. One bear killed; few signs of animal life seen since 3 p. m. yesterday. A solar halo from 7.30 a. m. to 10 a. m. Weather cloudy in the afternoon. Reached open water at 7 p. m. and immediately met with a large number of birds. Conical Rock in sight at 11 p. m. Rain began at 8 p. m. and ended at 10.30 p. m.

ELLIS, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	75 29	64 22	29.429	.....	32.5	32	30.5	92	NW.	Light.
7 a. m.	75 28	64 41	29.361	.....	36	35	30	79	NW.	Light.
11 a. m.	75 26	65 28	29.346	.....	36.5	36	35	94	SW.	West.
2 p. m.	.....	.....	.....	.....	34.8	.....	.....	.....	.....	.....
3 p. m.	75 41	66 20	29.386	.....	34.9	34.8	33.1	93	0	Calm.
7 p. m.	75 53	67 30	29.408	.....	34	33.5	32.5	94	NE.	Light.
11 p. m.	76 02	68 40	29.365	.....	34	34	34	100	NW.	Light.

Coast

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RELIEF PARTY AT THE ENGLISH CACHE, CAREY ISLAND, JULY 21st

PROTEUS IN PANDORA HARBOR.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
1 a. m.							32		
2 a. m.							31.8		
3 a. m.	0	0	0	2	Str	0	31.2	Cloudy	Ellis.
4 a. m.							32		
5 a. m.							32		
6 a. m.							31.8		
7 a. m.	Hidden.			10	Str	0	31.8	Cloudy	Ellis.
8 a. m.							31.8		
9 a. m.							31.7		
10 a. m.							31.8		
11 a. m.	0	0	0	9	Str	0	31.8	Cloudy	Lamar.
12 a. m.							32.5		
1 p. m.							33		
3 p. m.									
7 p. m.	Hidden.			10	Strat ..	0	37.1	Cloudy	Ellis.
8 p. m.							37		
9 p. m.							37.3		
10 p. m.							37		
11 p. m.	Hidden.			10	Strat ..	0	36.0	Cloudy	Ellis

Maximum: 40.2 at 11 p. m. Minimum: 31.7 at 7 a. m.; 30.5 at 11 p. m.

JULY 22.

Arrived at Pandora Harbor at 5.20 a. m. No ice could be seen in Smith Sound with a glass from the "crow's-nest." Observers went ashore to take time-sights. While on shore protographs were made of the harbor. Left Pandora Harbor at 7 a. m. There was scarcely a ripple on the water, and the photograph of Cape Alexander was made without difficulty from the deck as the vessel steamed away at full speed. At 11.36 a. m. met a solid ice-field extending from Cape Inglefield to Cape Sabine. Passed along the edge of this ice to Cape Sabine without finding a lead. Anchored in Payer Harbor at 2 p. m. Observers went ashore with magnetic and other instruments and had made five sets of observations for time and azimuth when they were recalled to the ship, which, at 7 p. m., proceeded northward through a lead extending toward Cape Albert, when near that point the heavy floes closed in and stopped the lead, an effort was made to ram a passage, but after many unsuccessful attempts this lead was abandoned, and another more favorable entered.

LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	78 05	73 22	29.619	.....	38.5	38	36.5	92	0	Calm.
7 a. m.	78 13	73 10	29.619	.....	40	38.5	36	86	0	Calm.
11 a. m.	78 45	73 40	29.712	.....	43.5	39.2	32.6	68	0	Calm.
3 p. m.	78 42	74 16	.....	.....	.....	.....	.....	.....	.....	.....
7 p. m.	78 42	74 16	29.744	.....	40.5	39.5	38	92	0	Calm.
11 p. m.	78 54	74 30	29.722	.....	35	34	32	89	0	Calm.

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
2 a. m.							35		
3 a. m.	3	Cir	0	2	Strat..	0	36	Fair	Lamar.
4 a. m.							36		
5 a. m.							36		
7 a. m.	2	Cum ...	0	0	0	0	36	Clear	Lamar.
9 a. m.							34.8		
10 a. m.							35.1		
11 a. m.	2	Cir....	0	0	0	0	32.8	Clear	Ellis.
12 m							33.4		
1 p. m.							31.2		
7 p. m.	2	Ci.-st ..	0	0	0	0	32.1	Clear	Lamar.
8 p. m.							32		
9 p. m.							30.8		
10 p. m.							30.5		
11 p. m.	4	Cir	0	0	0	0	30.1	Fair	Lamar.
12 p. m.							30.4		

Maximum: 45.0 at 3 and 11 p. m. Minimum: 31.5 at 7 a. m.; 30.2 at 11 p. m.

JULY 23.

The Proteus was nipped in the ice at 2 a. m. near the latitude of Cape Albert and held motionless for two hours. She was photographed in this position. At 4 a. m. the lead again opened and she steamed forward, but soon found that further progress northward was cut off by the impenetrable ice-pack, and a lead reaching back to Cape Sabine was entered at 9.40 a. m. At 2.50 p. m., when nearly through the dangerous ice, the floes again closed in upon the vessel crushing in her sides. She soon filled with water, but was sustained by the pressure of the floes until 6.05 p. m., when they separated and the Proteus gracefully passed out of sight. I made photographs of the the ship after she was abandoned and of the ice and general débris just as she sank. The lead in which the vessel was crushed was the same through which she attempted to reach Cape Albert on the previous day. Buchanan Strait was packed with ice which remained stationary; the outer edge of this formed one side of the lead, which extended from Cape Sabine to Cape Albert. The ice-pack of Smith Sound approached and receded from the Buchanan Strait ice with the rising and falling of the tide, causing regular alternate nips and openings so that, on the morning of the 23d, the vessel was enabled to pass unobstructed by the identical ice through which she had failed to force a passage on the previous evening, and was finally caught and crushed in ice through which she had passed without difficulty the day before. When the Proteus was crushed the same lead again opened and the ice-pack thus relieved drifted southward, the floe upon which our party took refuge drifted in a few hours from eight miles north of Cape Sabine to the southward of that cape; but on the following day, when the last boat left the floe, it was moving rapidly northward and was at that time a little north of Cape Sabine. The ice in Smith Sound was almost exclusively floe ice from 5 to 8 feet in thickness.

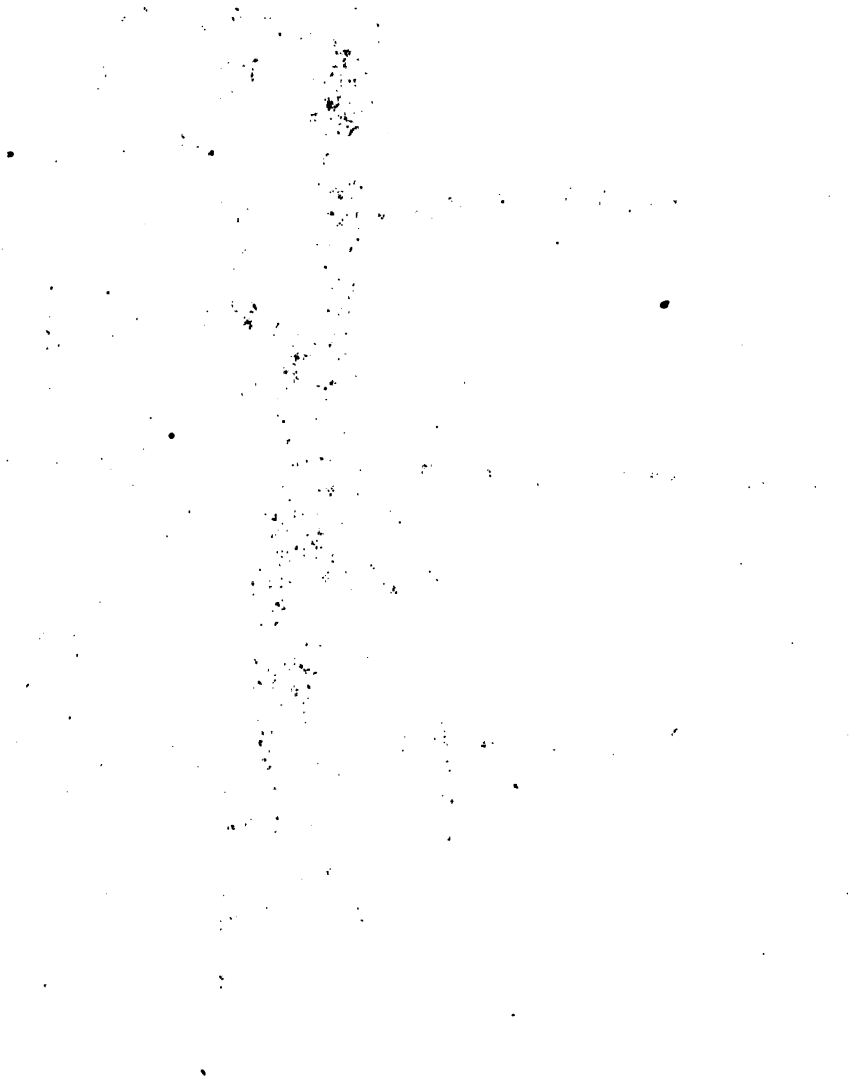
LAMAR, *Observer.*

Washington time.	Position.		Barometer.		Thermometer.		Dew-point.	Relative humidity.	Wind.	
	Latitude.	Longitude.	Actual.	Reduced.	Dry bulb.	Wet bulb.			Direction.	Velocity.
	° ′	° ′			°	°	°			
3 a. m.	79 06	74 05	29.722	.....	35.1	34.8	34.2	96	0	Calm.
7 a. m.	79 06	74 05	29.720	.....	40.5	38.5	35.5	82	0	Calm.
11 a. m.	79 03	74 23	29.704	.....	41.0	38	33.0	73	N.	Light.
3 p. m.	78 52	74 25	29.706	.....	.....	.....	.....	.....	.....	

| | | |

PROTEUS NIPPED IN THE ICE, JULY 23rd

BROKEN ICEFLOE THROUGH WHICH THE PROTEUS SANK
WHALE BOATS ON THE ICE IN THE BACKGROUND



THE PROTEUS ABANDONED, JULY 23RD

Washington time.	Clouds.						Water temperature.	State of weather.	Observer.
	Upper.			Lower.					
	Amount.	Kind.	Direction.	Amount.	Kind.	Direction.			
							°		
1 a. m.							30.2		
2 a. m.							30		
3 a. m.	1	Cir.	0	0	0	0	30	Clear	Ellis.
4 a. m.							30.5		
5 a. m.							31		
6 a. m.							31.2		
7 a. m.	2	Cir.	0	0	0	0	31.4	Clear	Ellis.
8 a. m.							31		
9 a. m.							30.9		
10 a. m.							31.3		
11 a. m.	2	Cl.-st.	0	0	0	0	33	Clear	Lamar.

Minimum 32° at 7 a. m.

JULY 24.

The regular observations ceased with the wreck of the Proteus. The following is a list of the instruments saved:

Two sextants, two artificial horizons, two station mercurial barometers, one aneroid barometer, one thermometer, four chronometers (two of which were afterwards left in the cache at Cape Sabine), the photographic instrument, and two boat compasses.

Weather clear and pleasant. The last boat landed on Cape Sabine at 3 p. m., and the party laid down upon the rocks to rest, after twenty-four hours of continual exertion.

LAMAR, *Observer.*

CAPE SABINE, *July* 25.

In morning foggy weather, light southerly winds. In afternoon, clearing weather, moderate northwesterly winds. Party left Cape Sabine for Pandora Harbor, Ellis with first whale-boat, Lamar with second whale-boat. When nearly half way across the sound a dense fog set in, obscuring both shores. Compass is very unreliable in these high latitudes, and boats could not be kept on original course.

LAMAR, *Observer.*

JULY 26.

At 12.30 a. m. made safe landing near Life-boat Cove. The water here was shallow, rocky, and dangerous even for our small boats. Light rain from 2 to 3 a. m. Very little vegetation on shore. Noises of a herd of walrus distinctly heard. Started for Pandora Harbor at 3.35 p. m. A large herd of walrus, estimated at five or six hundred in number, were lying upon northern side of Littleton Island, and many upon drifting ice-floes. Arrived at Pandora Harbor at 7.50 p. m., where camp was made. Light rain and southeasterly wind from 10 p. m. to 12 p. m.

LAMAR, *Observer.*

JULY 27.

Foggy weather. Observers ascended the mountain east of Pandora Harbor, over ten or twelve successive terrace-like flats and rises, to an estimated height of twelve hundred feet, at which point they passed above the fog. These flats were covered with loose stones, evidently brought down from the peaks above by descending ice. Outcrops, at an elevation of about one thousand feet, exhibited stratified sandstone, the strata varying from two to several inches in thickness and bearing well-defined ripple-marks. In some places pieces of a black sedimentary rock were abundant. The soil was generally a reddish clay, but where the black rock was located the soil was also black, and this rock could be seen in all the stages of disintegration.

Vegetation was scant, and the high mountains and deep ravines were covered with snow; heard noise of falling ice, like thunder, in direction of Crystal Palace Glacier. At Pandora Harbor were seen several varieties of flowers and mosses.

Birds were abundant, and several Arctic hares were killed. Fog began to clear away at 11 p. m.

LAMAR, *Observer.*

JULY 28.

At 4.30 a. m. boats left Pandora Harbor, but, after rounding Cape Alexander, fresh northwest wind forced them to seek safety near the shore. No place suitable for landing boats could be found until a cove on Cape Saumarez was reached, where there was a landing, but not a good one. The swell from the sea beats heavily upon the shore, so the boats had to be unloaded and hauled up on the beach. The cove showed signs of having been the mouth of a glacier. A few scattering bunches of moss were the only signs of vegetation. Fog set it an the entrance of Sontag Bay, where much ice was seen. At camp weather was clear and pleasant.

LAMAR, *Observer.*

JULY 29.

At 5.45 a. m. boats were under way. Calm, clear, and pleasant day. Birds and walrus abundant; one of the latter was shot, but it sank immediately. While crossing Murchison Sound heard almost continual crushing of ice in direction of the glaciers in Inglefield Gulf. The noise was not unlike that of distant thunder. Arrived at Northumberland Island at 8.10 p. m., and boats were moored with stones.

LAMAR, *Observer.*

JULY 30.

Eastern side of Northumberland Island was found to be almost barren, the formation being principally shale. The land is high and a glacier descends into the sea near the encampment. Several white hares were seen.

At 4.30 p. m. the boats started southward and soon passed a large school of white whales.

Clear and pleasant weather; moderate westerly, winds, varying to light northerly.

LAMAR, *Observer.*

JULY 31.

Landed in a small cove a little north of Cape Parry at 2 a. m. This cove was evidently the place of descent of a glacier, but there was no ice for half a mile east of the encampment. The mountains on either side were covered with snow, and a small glacier descended to the sea from the one on south side of the cove. Small well-worn bowlders covered the ground, the vegetation consisting of only a few bunches of moss. A flock of ducks and other birds were seen upon the water. The beach was sandy and covered with seaweed. At 5 a. m. a storm came on and continued during the entire day. Fresh easterly wind with continued rain or snow.

LAMAR, *Observer.*

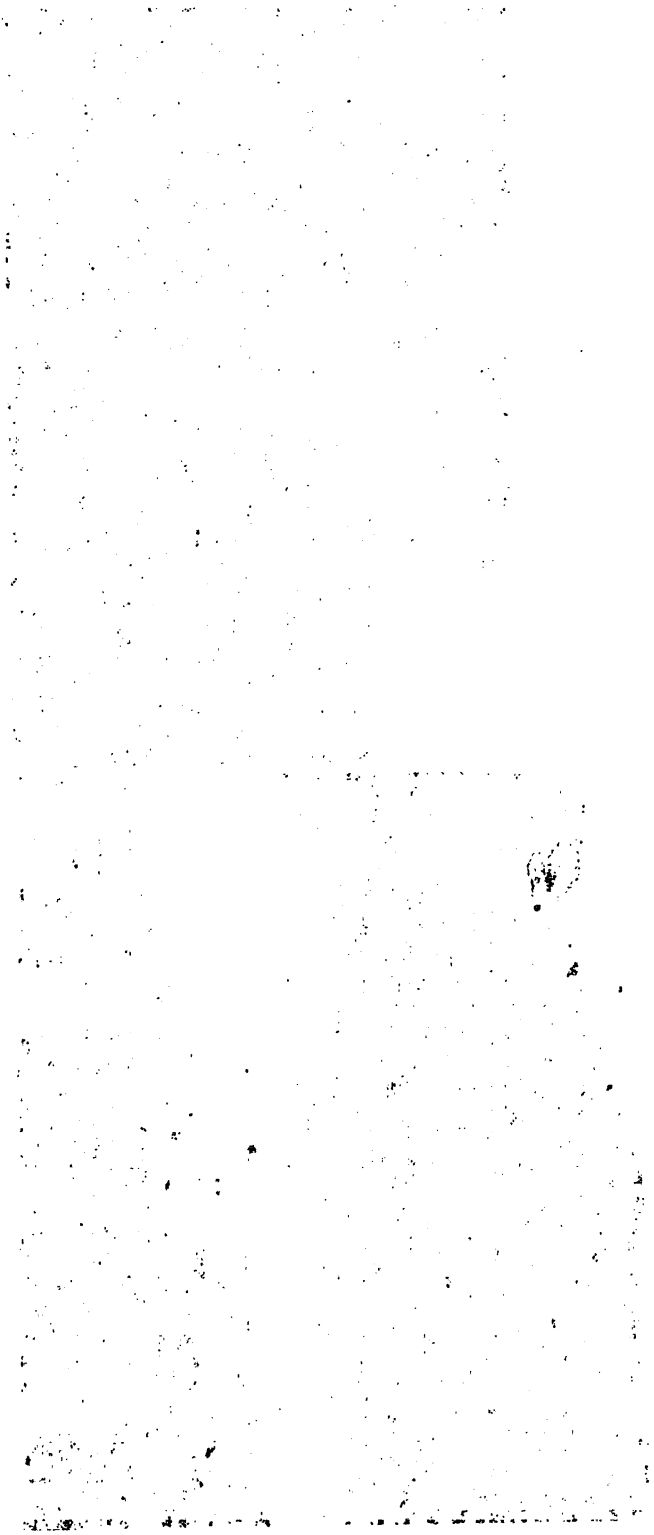
AUGUST 1.

The storm continued, wind shifting to the westward in the afternoon, a dense fog covering the water. The weather very disagreeable, sometimes snowing and at other times raining.

LAMAR, *Observer.*

AUGUST 2.

Rain ended early in the morning. At 3.30 a. m. the dense fog showed signs of clearing away. At 5.30 a. m. perfectly clear weather, except a strip of fog hanging over Northumberland Island. Got under way at 8.25 a. m., with moderate northwest breeze. At 11.45 a. m., when near Fitzclarence Rock, boats encountered large number of icebergs and floes which extended as far as could be seen with the glass. A lead was discovered near the shore which the boats reached at 2.30 p. m., after many



[illegible] were abundant and several Arctic hares were killed. Fog began to [illegible] at 11 p. m.

LAMAR, *Observer.*

JULY [illegible]

At 4.30 a. m. boats left Pandora Harbor, but after rounding Cape Alexander a northwest wind forced them to seek safety near the shore. No place suitable for landing boats could be found until a cove on the Saumatez was reached. There was a landing, but not a good one. The swell from the sea beats heavily upon the shore, so the boats had to be unloaded and hauled upon the beach. The coast gives signs of having been the result of a glacier. A few scattering branches of moss are the only signs of vegetation. Fog set in at the entrance of Sontag Bay, where ice was seen. At camp weather is clear and pleasant.

LAMAR, *Observer.*

JULY [illegible]

At 5.45 a. m. boats were under way. Calm, clear, and pleasant day. Birds, walrus, and plant; one of the latter was shot, but it sank immediately. While leaving Mecumsin Sound heard almost continuous crashing of ice in direction of Hayes's Englefield Gulf. The noise was not unlike that of distant thunder. Arrived at Northumberland Island at 8.10 p. m., and boats were moored with stones.

LAMAR, *Observer.*

JULY [illegible]

East [illegible] side of Northumberland Island was found to be almost barren of [illegible] being principally stone. The land is high and a glacier descends into the [illegible] from the encampment. Several white bears were seen.

At 4.20 p. m. the boats started southward and soon passed a large school of [illegible] whales.

Clear and pleasant weather; moderate westerly winds, varying to light westerly.

LAMAR, *Observer.*

JULY [illegible]

Landed in a small cove to the north of Cape P[illegible] at 2 a. m. This cove evidently the place of descent of a glacier, but there was no ice to be found at the end of the encampment. The mountains on either side were covered with snow, a small glacier descending to the sea from the one on the south side of the cove. Small worn bowlders constitute the moraine, the vegetation consisting of only a few kinds of moss. A flock of birds and other birds were seen upon the water. The cove was sandy and covered with seaweed. At 5 a. m. a storm came on and continued during the entire day. Fresh easterly wind with considerable rain and snow.

LAMAR, *Observer.*

AUGUST [illegible]

The storm continued, wind shifting to the westward in the afternoon, and covering the water. The weather very disagreeable, sometimes snowing and sometimes raining.

LAMAR, *Observer.*

AUGUST [illegible]

[illegible] ended early in the morning. At 3.30 a. m. the dense fog showed signs of clearing. At 5.30 a. m. perfectly clear weather, except a strip of fog back of the N[illegible]rthumberland Island. Got under way at 8.25 a. m., with moderate northerly [illegible]. At 11.45 a. m., when near Fitzclarence Rock, boats encountered large [illegible] bergs and floes which extended as far as could be seen with the glass. [illegible] was discovered near the shore which the boats reached at 2.30 p. m., after [illegible]

CAPE ALEXANDER

HEAD OF PANDORA HARBOR

T. Sinclair & Son, Lith. Phila.

SUNDERS ISLAND AT ENTRANCE TO SAUNDERS HARBOR

VIEW OF ICEBERGS AT SEA FROM SAUNDERS ISLAND.
AUGUST 4TH

changes of direction among the ice-floes and narrowly escaping a nip. The motion of the ice was very rapid. Continued course along the shore, with moderate northwest breeze until 5.30 p. m., when breeze died away. Large fields of ice were seen to the westward. Saunders Island was reached at 8 p. m. The scenery here was said by many to be the grandest met with by our party in the Arctic. On the western side the bluff rises perpendicularly for several hundred feet, and exhibits about twenty-five strata, each stretching horizontally from end to end of the bluff and differing from the others in color. Upon the top of the bluff are several turrets, the whole presenting a scene similar to the ruins of an ancient castle. We therefore called it "Castle Bluff." In its crevices myriads of birds were perched, and when a gun was fired they swarmed like bees above our heads. The southern portion of the island is flat and the soil is very fertile. Many varieties of flowers, mosses, and grasses were found. There were several old Eskimo huts on the southwestern point; bones were scattered in every direction; freshly taken bird-skins and seal-meat were drying in rock pens; seal-blubber was found and used for fuel, and a lame Eskimo dog was seen. This island is evidently the summer hunting ground of the Eskimos, yet none of them were seen upon it. Quite a number of Eskimos have been buried here. The tombs consist simply of pens of stones around the dead bodies, which are laid on top of the ground. Some of these graves contained two bodies.

LAMAR, *Observer.*

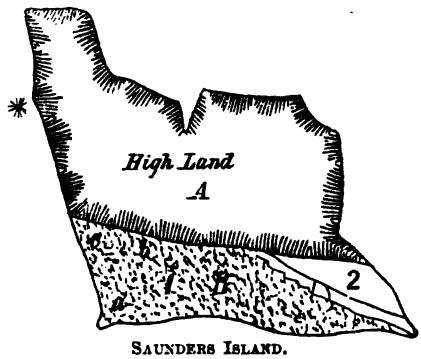
AUGUST 3.

Fog set in and detained the party. Two boats with hunting parties visited Castle Bluff and brought back a large number of birds.

In the accompanying drawing of Saunders Island:

(A) Shows the elevated part of the island.
(B) Lowlands.
(*) Castle Bluff.
(1) Fertile part of the island.
(2) Almost barren part.
(*a*) Position of the Eskimo huts.
(*b*) Cemetery.
(*c*) Position of the camp of expeditionary force.

Fog continued throughout the day.



SAUNDERS ISLAND.

LAMAR, *Observer.*

AUGUST 4.

At 4 a. m. fog began to clear away; weather calm. Made photographs of Castle Bluff and icebergs at sea. Boats under way at 5.50 a. m. At 9 a. m., when near Wolstenholm Island, moderate NE.E. breeze sprang up. Fog having set in and large quantities of ice being in sight, landed on Cape Athol at 12.30 p. m.

Cape Athol is high and the bluffs seemed to have about the same elevation as most of those along the Greenland coast. Here the elevation was determined with an aneroid barometer, with the following results:

Reading of barometer at base, before ascending 29.719
Reading of barometer on bluff (Cape Athol) 29.190
Temperature of the air, about 46° F.
Reading of barometer on returning 29.660

The result of this observation shows the elevation to be about 450 feet.

A blue fox, a deer, several white hares, and many birds were seen. There were many spots of luxuriant grass, and the turf or peat at our landing place was from 15 to 20 inches deep, and afforded fine fuel. At midnight there was a dense fog and a cold westerly breeze.

LAMAR, *Observer.*

AUGUST 5.

Weather continued foggy. Observer joined a hunting party and explored the country east of camp. After reaching an elevation of about eight or nine hundred feet the land was found to be flat, with a gentle rise to the eastward. Small patches of snow were occasionally seen. The soil was light sand and pebbles, the vegetation consisted of scattering tufts of grass and mosses. Many signs of foxes, hares, and deer were seen, but no birds, as they seem to confine themselves to the bluffs along the shore. An eastward course was pursued for about four miles over this plain, which extended as far as the eye could reach. The course was then changed to the southward, and, after walking about one mile in that direction, we descended into a fertile valley through which a creek of crystal water flowed. Along this valley were well-beaten reindeer-paths, and huge antlers they had shed were lying in every direction. Again we turned toward the east and followed the valley toward the interior for an hour, expecting every moment to see a herd of deer, so abundant were the recent signs of them, but the lateness of the hour forced us to turn our steps toward camp without seeing them. The valley was found to descend to the beach about three miles south of the camp. At its mouth it widens here the grass was very fine. The turf or peat was 15 to 20 inches in thickness. There we found seven or eight old Eskimo huts, broken in and covered with tall grass, and bones of various animals scattered over the ground. This place was by far the best location for a camp we had seen since leaving Pandora Harbor.

Many Eskimo fox-traps were found along the shore. These traps are constructed of stone, in a very simple manner. In afternoon fog was very heavy, threatening a storm. At 10 p. m. rain began, which soon changed into snow. At midnight stormy and cold, with rain and sleet.

LAMAR, *Observer.*

AUGUST 6.

Heavy rain during night and all were wetted. Rain or snow fell during the entire day and until late in the afternoon, when clouds cleared away toward the north.

LAMAR, *Observer.*

AUGUST 7.

Rain during night. At 10 a. m. clearing toward the north. At 11.50 a. m. boats were under way, with a moderate northerly breeze; passed Petowic glacier. Calm weather at 3.30 p. m.; a large amount of ice was in sight. At 4 p. m., near Conical Rock, met heavy floe ice and several large icebergs; boats worked through leads in this ice until 4.45 p. m., when the ice closed in from all directions, and boats were hauled up on the floe to prevent them from being crushed. Made photographs of boats, ice, and Conical Rock. At 6.53 p. m. lead opened to southward, and boats soon reached the south side of Conical Rock, from which the most favorable course through the ice was selected. Fair, pleasant weather.

Boats narrowly escaped being caught in the ice at midnight while off Parker's Snow Point.

LAMAR, *Observer.*

AUGUST 8.

Sea was covered with ice-floes and icebergs as far as the eye could reach, and young ice formed upon the open patches of water one-quarter of an inch in thickness. At 2.20 a. m. boats were hauled up in a cove, but started again for Cape York at 1.15 p. m. Fresh east wind. Proceeded about two miles, when further progress was prevented by the ice pack, and at 2.30 p. m. hauled boats upon the beach near a small glacier. The turf or peat was from one to two feet in depth, and afforded good fuel. Birds were abundant, and several seals were seen on the ice and several blue foxes on the shore.

At midnight, cloudy weather, cool east wind, just high tide. Ice was packing in to the shore and extended far out to sea. Both wind and tide influenced the direction of the drifting ice.

LAMAR, *Observer.*

AUGUST 9.

Ice receded from the shore a short distance with the falling of the tide. At 9 a. m. Lieutenant Colwell with six men started with ship's punt for Cape York, dragging boat over ice when navigation was impossible. The glacier near camp was furrowed on top by descending streams of water from melting snow on the mountains, and a large stream of water flowed upon the ground along the side of the glacier, washing away its foundation for twenty-five feet from outer edge. There were many holes of various sizes in the surface of the glacier, and upon examination it was found that they were caused by stones, lumps of earth, turf, deposits of birds, foxes, &c., upon the glacier, the ice melts away from such things very rapidly, causing them to sink beneath the surface. Large numbers of birds were killed. Snow began at 10.30 a. m. Ice began to drift away from shore at 4 p. m. Light snow continued throughout the remainder of the day.

LAMAR, *Observer.*

AUGUST 10.

At 1.15 a. m. boats were under way, with a fresh east wind, and ice drifting away from shore. Stopped in a little cove at 3.15 a. m., the weather being foggy and a storm threatening. A deer was seen on shore. Under way again at 6 a. m., and passed four small glacier mouths not charted. Shore was high, with numerous mossy coves, and birds were swarming around the cliffs. Reached the three Eskimo huts on west side of Cape York at 9.25 a. m., where Lieutenant Colwell's party was found. A large Eskimo village was reported to be on the eastern side of Cape York, to which place all the boats at once proceeded, though the weather was stormy. Cape York is a high bluff, and a glacier extends across it from the eastern to the western side, over which the Eskimos travel in dog sledges. While passing the mouth of this glacier we encountered heavy NE. wind and rough sea. Passing round the cape several deserted Eskimo huts were seen, and at 2.30 p. m. boats were stopped by the ice pack near the glacier, and were hauled upon shore. A quantity of seal-blubber was found in caches, some of which was used for fuel. Several Eskimos visited camp. Rain and snow storm began at 2.50 p. m. and continued remainder of day. Light easterly winds.

LAMAR, *Observer.*

AUGUST 11.

Rain-storm continued throughout the day, and the exposure to the weather was very severe, but the natives did not seem to suffer. The seal-skin clothing which our party wore soon became wet and of no protection, but the natives had used oil upon their clothing, which rendered it water-proof, and they always appeared comfortable.

LAMAR, *Observer.*

AUGUST 12.

Rain-storm continued. There are no means of communication between the Cape York Eskimos and those of the Danish settlements, and the language of the former differs materially from that of the latter, our Godhavn Eskimo dog-drivers seemed to make themselves understood, but had great contempt for their ignorance. They said the northern Eskimos were "all the same as rocks," and when they began to eat the white whale skin raw, they said "Cape York Eskimo all the same as dogs."

There were no signs of mixture with other races, as in the Danish Eskimo settlements, and we saw no evidences of a religion. Their dress is something like that of the Eskimos of the Danish settlements, bear-skin trousers being substituted for seal-skin by the men, and the women dispense with the fancy work upon their clothing and cleanliness of person common to the more southern Eskimos.

Clearing weather in afternoon; ice moving rapidly. Boats launched at 9 p. m., having with much difficulty and danger hauled them over ice for a mile to open water. The floe-ice was two feet thick, only three inches of which was above water.

LAMAR, *Observer.*

AUGUST 13.

Landed at 1 a. m. in large cove on western side of Cape York. Cloudy, threatening weather. The Eskimos visited camp. One of the women made a pair of seal-skin boots, such as the Eskimos wear, in two and a half hours. She worked rapidly, and used both needle and thimble naturally. A large quantity of green, red, and dark-colored snow was upon the mountain sides, and upon careful observation it was invariably found that on the hills above such snow there were patches of moss. This moss was colored differently, according to the different stages of decay in which it was found, and it was thought by the observer that there might be an intimate relation between this moss and the colored snow. A quantity of the colored snow was melted and filtered, and specimens of the moss gathered and preserved for future microscopic analysis.*

LAMAR, *Observer.*

AUGUST 14.

Cloudy weather. Rain commenced at 2 p. m. and soon afterwards changed into snow. Continued raining and snowing during the remainder of the day.

LAMAR, *Observer.*

AUGUST 15.

Rain and snow storm continued until 3.30 p. m., when there were indications of clearing weather. Observer thinks that stormy weather prevails at Cape York during the summer season. The cape is a high promontory, spanned by a large glacier, over which the warm, damp winds of Baffin and Melville bays continually sweep. The temperature of this moist air is reduced in the presence of the glacier, and fog, rain, or snow is the result. When our boats approached Cape York, from Conical Rock, the cape was enveloped in fog and rain, which continued uninterruptedly during the entire time we were in that neighborhood. Observer walked several miles west of Cape York and could see the sunlight upon the ice and water in the vicinity of Conical Rock, but the camp on the cape was enveloped in rain clouds. Large quantities of ice floes and icebergs extended from shore far out to sea.

LAMAR, *Observer.*

AUGUST 16.

Weather moderated somewhat. Preparation began at an early hour to cross Melville Bay. At 10 a. m. the last boat left the shore and all worked along together through the pack until 1 p. m., when open water was reached. The advance whale-boat, with volunteer crew commanded by Lieutenant Colwell, then bade good-bye to other boats and headed directly for Upernavik, with a fresh west-northwest breeze. At 2 p. m. sighted ice-pack to the eastward; wind soon increased to a gale accompanied by rain and snow, and rough sea. About 6 p. m. course was abandoned and boat ran before the wind, clear of ice.

LAMAR, *Observer.*

AUGUST 17.

Weather moderated about midnight. At 5 a. m. the sun was seen, and wind had decreased to a light breeze from the westward. About 10.30 a. m. there was a fresh breeze from SE., with every indication of another storm. Headed for a small island in sight to northeastward, but missed it in a thick snow squall which came up

* Lost while crossing Melville Bay.

about noon; sighted the island again about 1 p. m., but was a mile to leeward of it with sea too heavy to attempt reaching it. Ran for a line of icebergs to northeastward, to get out of the heavy sea and constantly increasing wind, and at 3 p. m. made fast to a small berg. Snowing heavily with increasing gale until midnight.

LAMAR, *Observer.*

AUGUST 18.

Storm continued, icebergs breaking in every direction. Four times the boat was pulled for safer places, with great danger of being swamped or crushed by the ice. At 3.30 a. m. weather moderated, and land (Thom Island) was soon seen to the eastward. Rowed against a head wind southward through the icebergs. When off Melville Monument a light NE. breeze sprang up and sail was spread. Weather during the remainder of the day was warm and pleasant. Birds were scarce, and only an occasional seal was seen. We were "off Cape Seldon at midnight and still among many bergs, with occasional strings of lump ice from the bergs."

LAMAR, *Observer.*

AUGUST 19.

At 12.30 a. m. passed a small uncharted island SW. of Cape Seldon, and returned to it at 9 a. m. on account of head winds. "Wind falling light, left at 11.30 a. m.; we pulled in for Red Head, and, wind dying out, changed course, at 3 p. m., to SSE. (true). Made sail at 6 p. m. to light east breeze. Very many bergs and occasional strings of lump ice were seen." Latitude by sextant observation at noon was 75° 45′. Clear and pleasant weather.

LAMAR, *Observer.*

AUGUST 20.

Sailed a SSE. course until 11 a. m., after which the oars were used. At 7.30 p. m. sighted Devil's Thumb.

Fair weather. Large quantities of ice were passed. The coast-line is a continual glacier. Coast very imperfectly charted. Few birds or seals were seen. Latitude at noon by sextant observation was N. 74° 50′.

LAMAR, *Observer.*

AUGUST 21.

Light northerly breeze from 1 a. m. to 7 a. m. Clear and pleasant weather. Oars were pulled until 4 p. m., when light NNW. breeze began. Dense fog bank settled at 6 p. m. Calm at 7 p. m. Cold, foggy weather until midnight. Latitude at noon by sextant observation, N. 74° 16′.

LAMAR, *Observer.*

AUGUST 22.

Clear and cool. Light northerly wind from 2 a. m. to 5 a. m. Fresh NNW. breeze at 9 a. m., which increased to moderate gale. Rough sea. Dense fog at noon, therefore no determination of position could be made. At 6 p. m. landed on island about 24 miles north of Upernavik. Fog soon cleared away and weather moderated. At 9.30 p. m. continued southerly course through the net-work of islands which extend along the coast. Northerly breeze.

LAMAR, *Observer.*

AUGUST 23.

Clear and pleasant, with heavy swell. Wind died away at 12 midnight. Reached Upernavik at 3.30 a. m., and soon learned that the Yantic had left that place for Godhavn only six hours before our arrival. Our party received the greatest kindness at the hands of the governor, who seemed to think he could not do too much for our

comfort. The natives were equally kind. I made a photograph of our party in the whaleboat, which had delivered us, and at 2 p. m. we left Upernavik for Godhavn, in an open launch owned by the governor. Governor Miller, of Proven, accompanied us as far as his home. This gentleman spoke excellent English and seemed to take pleasure in giving any desired information. To him I am indebted for the following information:

The Eskimos live by hunting. The governors purchase from them blubber, furs, &c., and supply them with whatever they desire from the stores which are sent out annually from Denmark. Sugar, tea, and tobacco these natives will have as long as they possess anything salable. They are very improvident, and when game is plentiful they eat, drink tea, and smoke incessantly, and trade extravagantly at the store. Generally the hair of the women is braided into a long bunch on the back of the head and tied with ribbon, the color of which is an index to her hymeneal condition, viz: Blue distinguishes a married woman; black, a widow; a mixture of black and white, a widow who is a candidate for matrimony; red, a maiden, and green an unmarried mother. These customs are less strictly observed in the North Greenland district, where some few wear their hair like the Danes.

Seals are caught by shooting or by nets. The netting season extends from the first of November until spring; while the ice is thick holes are cut into it and nets set; the remainder of the year they are shot upon the ice. Seals afford most blubber in their breeding season, when they are very fat. White whales are caught in nets from the fifteenth of September to fifteenth of October, just one month; after that time they travel south and are seen no more until spring, when they return north as the ice breaks up and passes south. The blubber of the white whale is mixed with that of the seals and made into oil. The Eskimos eat the skin, and it is considered to be a great anti-scorbutic. Walrus, like seals, are abundant during the season of ice, but they are always found where swift currents keep the ice well broken. Seals feed upon the small animal life found in these waters, walrus feed upon seals, like the white bear, and meat of the two differs very little. All the sea birds go north in spring to breed, and return to South Greenland in winter, the eider ducks and white gulls remaining latest in the fall.

At 11 p. m. Proven was in sight. The breeze died down and all were called to the oars, so my interrogations ceased.

LAMAR, *Observer.*

AUGUST 24.

Reached Proven at 4 a. m. Eskimos about the same in dress and habits as those of Upernavik and Godhavn. The harbor is well protected by an island, at the entrance. Seven hundred casks of seal oil are sent annually from this place to Denmark.

Governor Miller takes regular meteorological observations, and I was kindly invited into his observatory to see his instruments and records. Made photographs of Proven and the governor's house.

Our boat was underway again at 3.30 p. m., in clear, calm, and pleasant weather. Heavy dew at midnight.

LAMAR, *Observer.*

AUGUST 25.

Light northerly breeze from midnight to 1 a. m; almost calm during remainder of day.

The Margaritta, upon which we were making passage, was a peculiarly constructed little boat of the following dimensions: thirty-six feet six inches stem to stern; eleven feet in beam; four feet six inches in hold; thirty-four feet eight inches length of keel; the beam, seven feet three inches from stem, was ten feet six inches. Rig, foresail twenty by eleven feet, mainsail twenty by fifteen feet, jib; and an additional square sail fifteen by fifteen feet; masts, twenty-eight feet six inches; oars, nineteen

comfort. The natives were especially kind. I made a photograph of our party and the vessel which had delivered us, and at 2 p. m. we left Upernavik for Godhavn, the seat of government for which is owned by the government. Governor Miller, of Proven, accompanied us as far as his home. This gentleman spoke excellent English and seemed to take pleasure in giving us desired information. Two pilots were employed for the inside route.

The next morning we reached Godhavn. The government purchases from them blubber to feed the dogs, for which they receive from the stores when are sent out annually from Denmark. Sugar, tea, and tobacco are also furnished. These natives will have a long winter before them, as the sun is absent for about three months, and when gone is pretty cold. Their food consists of fish, seal, and bear meat, and their extravagance is at the store, especially the hair of the seal, which is used for making long boots from the back of the head and neck. When, the government vessel arrives, it is overhauled by myself and condition. The men during the day were most of them dressed in a dress of a mixture of black and white sealskin, which is a dull color. The women were dressed in red, blue, and green and many other colors. These clothes are bought at the stores and are made by the women themselves. They are very fond of the Danes.

Seals are caught by harpooning at holes. The time of this season extends from the first of November until the middle of April; when the ice is thick holes are cut into it and nets placed under the ice. Bears are shot on the ice. Seals afford most food to the natives during the breeding season, when they are very fat. White whales are caught in nets in the fiords. Sept. 1st to 8th is the season of Orca whales. For one month after this they travel southward, and are seen on the coast in spring, when they return. After the ice breaks up and passes off the number of the white whale is small. The skin of these is used and made into soles for the skin boots and it is said to be a great delicacy to eat the blubber. Many seals are also taken during the season of open water. They always form a hole with their nose to keep the ice well broken. Seals upon the land are an easy life for bears, which feed upon seals, and the white bear, and next to them are dogs. Foxes are few. Little. All the sea birds go south in spring to breed. Land birds go south in winter, the eider ducks and the gull's remaining latest of the fall.

At 11 p. m. Proven was in sight. The breeze died down and all were called on deck, as they intended to pass close

LAMAR, *Observer*.

AUGUST 24.

Reached Proven at 4 a. m. I know about the same in regard to the harbor as Upernavik and Godhavn. The harbor is well protected by an island, at the entrance. Some hundred casks of oil are sent annually from this place to Denmark.

Governor Miller has regular meteorological observations, and I was kindly invited to observe. Access to records and reports. Made photographs of this and the governor's house.

Our boat was underway again at 7:30 p. m., in clear, calm, and pleasant weather, and we have now left Proven.

LAMAR, *Observer*.

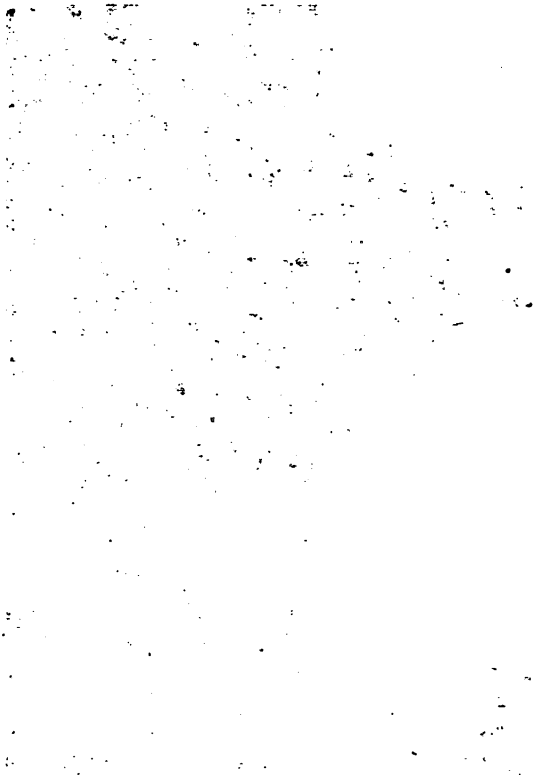
AUGUST 25.

Early this morning [illegible] the Labrador coast during the night. [illegible] upon which we were looking passage was peculiarly picturesque. [illegible] the following are the dimensions: This one was five hundred and [illegible] feet six inches to the [illegible] thirty-four inches in height. [illegible] was seven feet three inches and the second was five feet six inches. Each [illegible] was twelve feet, four [illegible] by fifteen feet; and an [illegible] was [illegible] by fifteen feet [illegible], twenty-one feet six inches [illegible].

UPERNAVIK.

T Sinclair & Son. Lith. Phila.

SAILORS ASHORE WITH THE ESKIMO GIRLS,
UPERNAVIK. (BY SPENCER).



ESKIMO GIRLS – UPERNAVIK.

T. Sinclair & Son, Ltd. Publ.

ESKIMOS IN THEIR KYAKS – UPERNAVIK

42.2

THE DANISH LAUNCH MARGARETT IN WHICH LIEUT. COLWELL'S PARTY MADE PASSAGE FROM UPERNAVIK, TO GODHAVN IN SEARCH OF THE U.S.S. YANTIC

T. Sinclair & Son, Lith. Phila.

LIEUT. COLWELL AND PARTY IN SECOND WHALE BOAT JUST BEFORE IT WAS EXCHANGED FOR THE MARGARETT AUG. 23RD

THE DANISH LAUNCH MARGARETT IN WHICH LIEUT COLWELLS PARTY MADE PASSAGE FROM UPERNAVIK TO GODHAVN IN SEARCH OF THE U.S.S. YANTIC

LIEUT COLWELL AND PARTY IN SECOND WHALE BOAT JUST BEFORE IT WAS EXCHANGED FOR THE MARGARETT. AUG 1883

PROVEN.

T. Sinclair & Son. Lith. Phila.

THE GOVERNOR'S HOUSE - PROVEN

feet. Only the fore-peak was decked over. The Danish colors flew from her mainmast. Light northerly breeze during latter part of day. Heavy dew at midnight; temperature of air, 36°.

LAMAR, *Observer.*

AUGUST 26.

Light NNW., breeze began at 6 a. m., soon increasing to moderate breeze, and continued until 10 p. m. Longitude at noon, by sextant observation, 71° 27′. Clear and pleasant weather.

LAMAR, *Observer.*

AUGUST 27.

Midnight to 8 a. m. clear and pleasant weather, light northerly breezes. At 7.30 a. m., off Noursook, several natives came out in their kyaks; at 10 a. m. they were followed by the governor of the place, and news was learned of the Yantic. At 1 a. m. we entered Waigat Strait. At 3.30 p. m. light NW. breeze began and continued until 11.30 p. m., when it increased to moderate breeze. At midnight, dark and cloudy, but very warm. Icebergs very phosphorescent. Some of them appeared as distant firelights.

LAMAR, *Observer.*

AUGUST 28.

Moderate NW. breeze from midnight to 4 a. m., and light NW. breeze from 4 a. m. to 6 a. m., when it became calm. Foggy at 8 a. m., clearing at 10 a. m. Clear and pleasant weather during remainder of day. Waigat Strait is a beautiful strip of water. The high lands on each side make it appear much more narrow than it really is. One of the men said, as we passed through, that it appeared to him to be about 2 miles wide, and it does not appear broader, yet it is charted at about 10 miles. Passed Kudlisōet coal mines at 9 p. m. Cloudy at midnight.

LAMAR, *Observer.*

AUGUST 29.

Midnight to noon, dark cumulo-stratus clouds; light breezes. At 4.30 p. m., passed the Eskimo village, near Oyorsosook, several natives came out in their kyaks. A moderate SE. breeze was blowing around the cape, and continued until midnight. Occasional showers of rain.

LAMAR, *Observer.*

AUGUST 30.

Southeasterly wind continued. Rounded the cape at 4 a. m. At 11 a. m. breeze died away. At 5 p. m. light easterly breeze sprang up, but at 9 p. m. it changed to stiff ENE. wind, and continued until midnight.

LAMAR, *Observer.*

AUGUST 31.

The favorable wind continued, and the low land upon which Godhavn is situated was sighted at 1 a. m. At 2.30 were off the landmark at Godhavn. Sails were reefed and an attempt was made to beat into the harbor, as the wind was blowing directly out of the entrance. After beating for three hours and making little progress our boat was carried against the rocks on south side of channel (6.10 a. m.). I was sent with signal flag to signal the Yantic for assistance. Reaching a rock from which her decks could be seen, the attention of her officers was soon gained and the following message was sent:

"Lieutenant Colwell's boat on rocks at mouth of harbor; wants help." An acknowledgment was at once made and the dingy sent for me to come aboard, where the situ-

ation was soon explained to Captain Wildes, and boats were at once sent to Lieutenant Colwell's assistance, the Margeritta was reached and at at 8.40 a. m., she was towed alongside the Yantic, and our party were received with three loud cheers.

LAMAR, *Observer.*

SEPTEMBER 2.

Made comparison of aneroid barometer, No. 4539, with Upernavik barometer, which consisted of only one set of readings, as follows:

Upernavik barometer.	Temperature.	Aneroide. No. 4539.
mm.	*C.*	
756.1	8.2	29.722

Using a correction of +.022 to No. 4539, which was determined by comparison with standard marine barometer on board the Proteus, July 12, 1883, I find that a difference of + 0.015 inches, or + 0.4 mm., exists between the two barometers.

LAMAR, *Observer.*

T. Sinclair & Son, Lith. Phila.

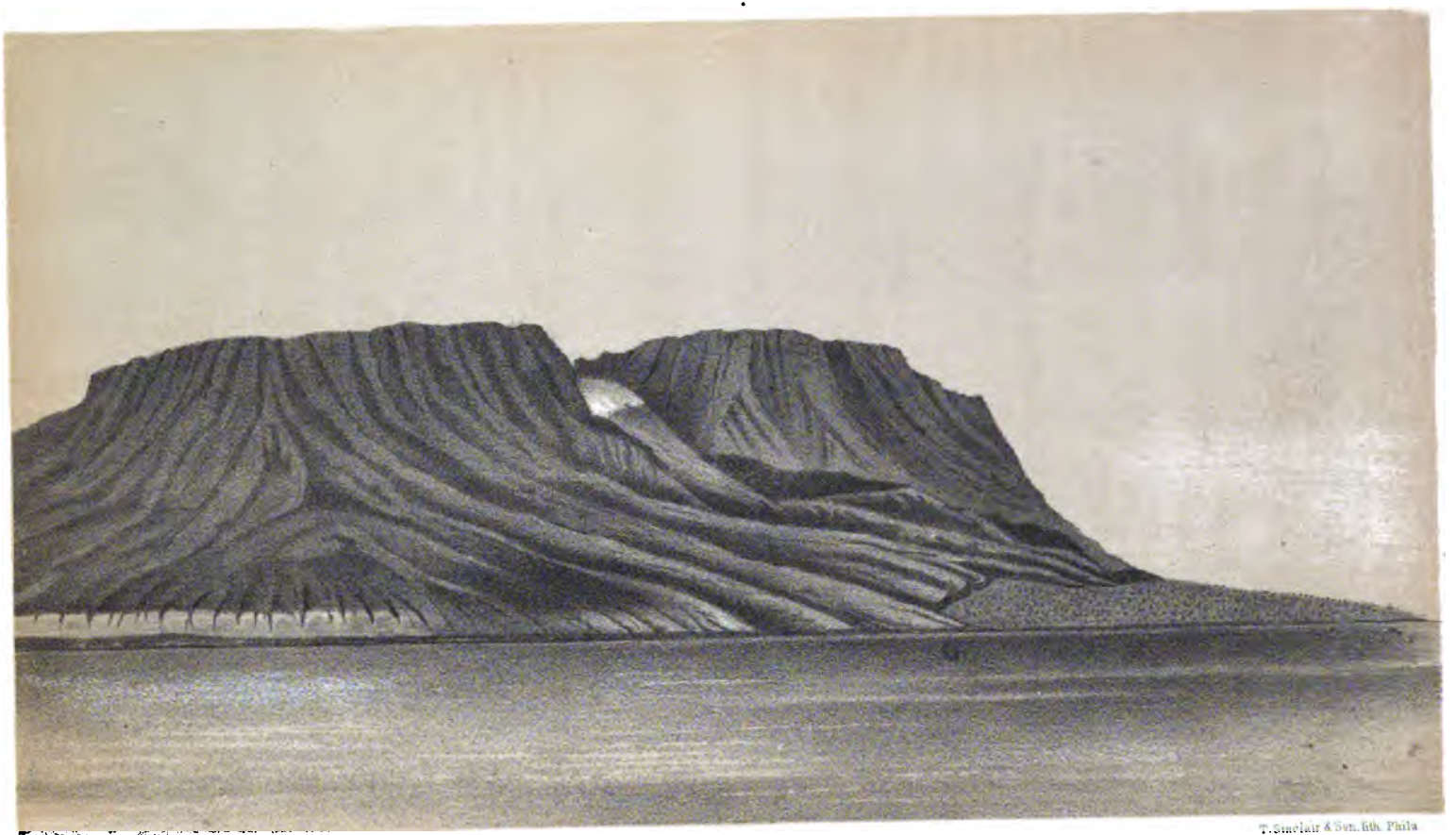
ESKIMO HUT AT GODHAVN

PHOTOGRAPHED FROM A SKETCH BY H.C. DREER.

T. Sinclair & Son, Sc. Phila.

ESKIMO HUT AT GODHAVN.

PHOTOGRAPHED FROM A SKETCH BY H.C. DRESEL.



T. Sinclair & Son, lith. Phila.

KUDLICET COAL MINES – DISCO ISLAND

PHOTOGRAPHED FROM A SKETCH BY H.C. DRESEL.

MAGNETIC OBSERVATIONS.

SAINT JOHN'S, NEWFOUNDLAND, *June* 28, 1883.

The dip circle and magnetometer were mounted in Saint John's, a little west of the intersection of the two walks, in an old cemetery on Church Hill. The dip circle used was one of the old style, the circle being graduated to twenty minutes. It was not a very delicate instrument, the different readings of the needle in the same position often differing by as much as twenty minutes. The results given are the means of three successive readings of the needle in each position. Observations for relative intensity with Lloyd needle and weights were taken, but, as the needle and weights were afterwards lost, together with observations at base station in Washington, D. C., they are considered of no value. A magnetometer with detached theodolite was used. The constants were determined by observers before leaving Washington. These determinations were lost.

Results of observations at Saint John's.

	o ′
Dip (mean of 4 sets)	74 47.0
Magnetic moment (mean of 2 sets)	0.446
Horizontal intensity (mean of 2 sets)	3.292

DIP.

(Dip Circle No. 8. Needle No. 1.)

I.

[Time of beginning, 9.25 a. m. Time of ending, 9.55 a. m. Observer, Ellis.]

	Polarity of marked end N.			Polarity of marked end S.	
	Circle east.	Circle west.		Circle west.	Circle east.
	o ′	o ′		o ′	o ′
Face east, S.	75 00	74 52.3	Face west, S.	75 21.3	75 18.3
Face east, N	75 10	74 45.6	Face west, N	75 10.0	75 27.7
Mean	75 05	74 48.9	Mean	75 15.6	75 23.0
Face west, S	74 33.3	74 41.6	Face east, S.	73 59.6	73 50.7
Face west, N	74 40.0	74 25.6	Face east, N	73 49.7	73 58.3
Mean	74 36.6	74 33.6	Mean	73 54.6	73 54.5
Mean, face east and face west with circle east.	o ′ 74 50.8		Mean, face west and face east with circle west.	o ′ 74 35.1	
Mean, face east and face west with circle west.	74 41.2		Mean, face west and face east with circle east	74 38.8	
Mean, circle east and circle west	74 46.0		Mean, circle east and circle west	74 36.9	

Mean of polarities, circle east (marked end N) and circle west (marked end S)	74° 42′.9
Mean of polarities, circle west (marked end N) and circle east (marked end S)	74 40.0
Resulting dip	74 41.4

Circle in magnetic prime vertical:

		o ′
Circle N.	Needle N	36 33
	Needle S	35 40
Circle S.	Needle N	34 37
	Needle S	33 54
	Magnetic meridian reads	35 11

II.

[Time of beginning, 10 a. m. Time of ending, 10.45 a. m. Observer, Lamar.]

	Polarity of marked end S.			Polarity of marked end N.	
	Circle east.	Circle west.		Circle west.	Circle east.
	° ′	° ′		° ′	° ′
Face east, S.	73 55.0	73 35.0	Face west, S	74 31.6	75 01.7
Face east, N	74 05.0	73 31.6	Face west, N	74 35.0	75 05.0
Mean	74 00.0	73 33.3	Mean	74 33.3	75 03.4
Face west, S	75 28.3	75 26.6	Face east, S.	75 01.7	75 03.3
Face west, N	75 33.3	75 18.3	Face east, N	75 01.7	75 10.0
Mean	75 30.8	75 22.4	Mean	75 01.7	75 06.6
	° ′			° ′	
Mean, face east and face west with circle east...	74 45.4		Mean, face west and face east with circle west...	74 47.5	
Mean, face east and face west with circle west..	74 27.8		Mean, face west and face east with circle east ...	75 05.0	
Mean, circle east and circle west	74 36.6		Mean, circle east and circle west	74 56.2	

Mean of polarities, circle east (marked end S) and circle west (marked end N)..... 74° 46′. 4
Mean of polarities, circle west (marked end S) and circle east (marked end N)..... 74 46 . 2
Resulting dip ..... 74 46 . 3

Circle in magnetic prime vertical:

		° ′
Circle N.	Needle N	31 45
	Needle S	38 56
Circle S.	Needle N	31 22
	Needle S	38 56
Magnetic meridian reads		35 15

III.

[Time of beginning, 11 a. m. Time of ending, 11.23 a. m. Magnetic meridian reads 35° 15′. Observer, Ellis.]

	Polarity of marked end N.			Polarity of marked end S.	
	Circle east.	Circle west.		Circle west.	Circle east.
	° ′	° ′		° ′	° ′
Face east, S.	75 00.0	75 31.7	Face west, S	75 30.7	75 18.7
Face east, N	75 07.3	75 30.0	Face west, N	75 21.7	75 23.0
Mean	75 03.6	75 30.8	Mean	75 26.2	75 20.8
Face west, S	74 29.3	74 33.3	Face east, S.	74 00.0	73 51.7
Face west, N	74 35.0	74 22.0	Face east, N	73 50.0	74 01.7
Mean	74 32.2	74 27.6	Mean	73 55.0	73 56.7
	° ′			° ′	
Mean, face east and face west with circle east...	74 47.9		Mean, face west and face east with circle west...	74 40.6	
Mean, face east and face west with circle west..	74 59.2		Mean, face west and face east with circle east ...	74 33.7	
Mean, circle east and circle west	74 53.6		Mean, circle east and circle west	74 37.2	

Mean of polarities, circle east (marked end N) and circle west (marked end S) ..... 74° 44. 2
Mean of polarities, circle west (marked end N) and circle east (marked end S)..... 74 46. 4
Resulting dip..... 74 45. 4

IV.

[Time of beginning, 11.30 a. m. Time of ending, 12 m. Magnetic meridian reads 35° 15′. Observer, Lamar.]

	Polarity of marked end S.			Polarity of marked end N.	
	Circle east.	Circle west.		Circle west.	Circle east.
	° ′	° ′		° ′	° ′
Face east, S.	74 05.0	74 15.0	Face west, S.	74 48.3	74 45.0
Face east, N.	74 10.0	74 08.3	Face west, N.	74 41.7	74 50.0
Mean	74 07.5	74 11.7	Mean	74 45.0	74 47.5
Face west, S.	75 25.0	75 30.0	Face east, S.	75 30.0	74 58.3
Face west, N.	75 33.3	75 25.0	Face east, N.	75 21.7	75 06.7
Mean	75 29.2	75 27.5	Mean	75 25.8	75 02.5
Mean, face east and face west with circle east	° ′ 74 48.4		Mean, face west and face east with circle west	° ′ 75 05.4	
Mean, face east and face west with circle west	74 49.6		Mean, face west and face east with circle east	74 55.0	
Mean, circle east and circle west	74 49.0		Mean, circle east and circle west	75 00.2	

Mean of polarities, circle east (marked end S) and circle west (marked end N) ..... 74° 56′.9
Mean of polarities, circle west (marked end S) and circle east (marked end N) 74 52.6
Resulting dip 74 54.6

HORIZONTAL INTENSITY.

I.

[Deflections. Instrument, magnetometer No. 2. Magnet, T. V. 3, deflecting in magnetic prime vertical. Magnet, T. V. 4, suspended. Observer, Ellis.]

Magnet.	North end.	Time.	Temp. t	Scale readings.	Alternate means.	Differences.
		h. m.	°			
West.	W.	3 31	65.0	43.5		
	E.	p. m.		125.0	43.45	81.55
	W.			43.4	125.00	81.60
	E.			125.0		
						81.575
East.	E.			127.4		
	W.			42.0	127.55	85.55
	E.			127.7	42.15	85.55
	W.	3 45	65.0	42.3		
		p. m.				85.55
Means.			65.0		$2u$	83.562

Dist., $r = 2.0$ feet. Log $r = 0.30103$

Computation: $\frac{m}{H} = \frac{1}{2} r^3 \tan u \left(1 - \frac{P}{r^2} \ldots\ldots\right)$

Tors. cir.	Scale.		Mean.	Diff's.		Logarithms.		Logarithms.
							d.	
59	82.0	89.2	85.6		$v =$ 11′.81		$u =$ 41.781	1.62098
				4.2	5400′ + v'	3.73334	1 div'n = 2.78	0.44404
84	75.1	87.8	81.4		5400 (ar. co.)	6.26761	$1 + \frac{h}{f}$	0.00095
				8.2				
84	80.4	98.8	89.6		$1 + \frac{h}{f}$	0.00095		2.06597
				4.6				
59	80.0	90.0	85.0				$u =$ 116′.39	
							$=$ 1° 56′.4	
							Tan u	8.52984
							r^3	0.90309
							$\frac{1}{2}$	9.69897
Mean $v = 4.25$							$\frac{m}{H}$	9.13190

OSCILLATIONS.

[Instrument, magnetometer No. 2. Magnet, T. V. 3. Chronometer, M. T. 5695. Daily rate, 1.5 s. losing on mean time. Observer, Ellis.]

Number of oscillations.	Chronometer time.	Temp. t'	Extreme scale readings.		Time of 66 oscillations.
	h. m. s.	°			m. s.
0	2 22 55.5	65	32	136	
6	23 50.4				
12	24 45.0				
18	25 39.7				
24	26 34.0				
30	27 29.2				
36	28 23.6				
66	32 58.0				10 02.5
72	33 53.0				10 02.6
78	34 47.9				10 02.9
84	35 43.0				10 03.3
90	36 37.4				10 03.4
96	37 32.3				10 03.1
102	38 26.5	65	43	126	10 02.9
	Means.	65			10 02.9571

[Coefficient of torsion. Value of one scale division = 2'.35.]

Tors. circle.	Scale.		Mean.	Diff's.		Logarithms.
54	82.1	84.5	83.3	8.0	$v = 7'.285$	
29	78.1	82.5	80.3	6.5	$5400' + v'$	3.73298 6.26761
79	82.6	91.0	86.8	2.9	5400 (ar. co.)	0.00059
54	80.2	87.6	83.9		$1 + \frac{h}{f}$	
Mean $v = 3.1$						

COMPUTATION.

$$T^2 = T'^2 \left(1 + \frac{h}{f}\right) (1 - [t' - t]\, q)$$

	s.
Observed time of 66 oscillations	= 602.9571
Time of 1 oscillation	= 9.13572
Correction for rate	= +0.00017
$T' =$	9.13587

			Logarithms.
q	0.00027	T'	0.96075
$t' - t$	00	T'^2	1.92150
$(t' - t)\, q$	.00000	$1 + \frac{h}{f}$	0.00059
$1 - (t' - t)\, q$	.00000	$1 - (t' - t)\, q$	0.00000
		T^2	1.92209
$m H = \frac{\pi^2 K}{T^2}$ $m = 0.446$		(ar. co.) T^2	8.07791
		π^2	0.99430
$H = 3.291$		K	1.09438
		$m H$	0.16659
		m	9.64924
		H	0.51735

Observations of deflections: Date, June 28. Hour, 3 p. m. Temperature, $t = 65°.0$.

	$\frac{m}{H}$	9.13190
	$m H$	0.16659
	m^2	9.29849
	m	9.64924

HORIZONTAL INTENSITY.

II.

[Deflections: Instrument, magnetometer No. 2. Magnet, T. V. 3, deflecting in magnetic prime vertical. Magnet, T. V. 4, suspended. Observer, Ellis.

Magnet.	North end.	Time.	Temp. t.	Scale readings.	Alternate means.	Differences.
West.	W.	h. m.	°	28.7		
	E.	3 53	65.0	140.6	28.65	111.95
	W.	p. m.		28.6	140.60	112.00
	E.			140.6		
						111.975
East.	E.			144.0		
	W.	4 10	65.0	27.5	144.00	116.50
	E.	p. m.		144.0	27.45	116.55
	W.			27.4		
			65.0			116.525
Means.			65.0		2 u	114.25

$r = 1.8$ feet. Log. $r = 0.25527$.

Computation: $\frac{m}{H} = \frac{1}{2} r^2 \tan. u \left(1 - \frac{P}{r^2} \ldots\ldots\right)$

Mean $v = 4.25$.

	Logarithms.		d.	Logarithms.
$v = 11.81$		$u =$	57.12	1.75679
$5400' + v'$	.73334	1 division $=$	2'.78	0.44404
5400 (ar. co.)	6.26761	$1 + \frac{h}{f}$		0.00095
$1 + \frac{h}{f}$	0.00095	$u = 159'.14 = 2° 39'.1$		2.20178
		Tan. u		8.66570
		r^2		0.76581
		$\frac{1}{2}$		9.69897
		$\frac{m}{H}$		9.13048

OSCILLATIONS.

[Instrument, magnetometer No. 2. Magnet, T. V. 3. Chronometer, M. T. 5695. Daily rate, 1.5 S. losing on mean time. Observer, Ellis.]

Number of oscillations.	Chronometer time.	Temp. t',	Extreme scale readings.		Time of 72 oscillations.
	h. m. s.	°			m. s.
0	2 45 33.0	65.0	29	135	
6	46 27.2				
12	47 22.7				
18	48 17.5				
24	49 12.4				
30	50 07.5				
36	51 02.5				
		65.5			
72	56 31.2				10 58.2
78	57 26.5				10 58.3
84	58 21.0				10 58.3
90	59 15.8				10 58.3
96	3 00 10.5				10 58.1
102	01 06.0				10 58.5
108	02 07.0	66.0	40	124	10 58.2
	Means.	65.5			10 58.414

[Coefficient of torsion. Value of one scale division = 2'.35.]

Tors. circle.	Scale.		Mean.	Diff's.		Logarithms.
54	82.6	84.6	83.6		$v = \frac{7'.52}{7.52}$	
				2.9	$5400' + v'$	3.73299
29	76.4	85.0	80.7		5400 (ar. co.)	6.26761
				6.4		
79	78.9	95.3	87.1			0.00060
				3.5		
54	76.3	90.8	83.6		$1 + \frac{h}{f}$	
Mean $v = 8.2$						

COMPUTATION.

$$T^2 = T'^2 \left(1 + \frac{h}{f}\right) (1 - [t' - t]\, q)$$

	s.
Observed time of 72 oscillations	= 658.414
Time of 1 oscillation	= 9.14464
Correction for rate	= +0.00017
T' =	9.14481

			Logarithms.
$\frac{q}{t' - t}$	0.00027 + 0°.5	T'	0.96117
		T'^2	1.92234
$(t' - t)\, q$	0.00013	$1 + \frac{h}{f}$	0.00060
$1 - (t' - t)\, q$	0.99987	$1 - (t' - t)\, q$	9.99995
		T^2	1.92289
$mH = \frac{\pi^2 K}{T^2}$ $\quad m = 0.445$		(ar. co.) T^2	8.07711
		π^2	0.99430
$H = 3.294$		K	1.09438
		mH	0.16579
		m	9.64814
		H	0.51765
		*m	
		H	9.13048
		mH	0.16579
		m^2	9.29627
		m	9.64814

* Observations of deflections: Date, June 28. Hour, 4 p. m. Temp. $t = 65°.0$.

GODHAVN, GREENLAND, *July 8–10th*, 1883,

The magnetometer was mounted near the center of the village of Godhavn, the church bearing W., governor's dwelling W. NW., store-house N., carpenter's shop NE. The dip circle was to the northward, and in the same magnetic meridian as the magnetometer. The large theodolite, with which the azimuth of the mark was determined, was placed in a line with theodolite of magnetometer and the mark. The mark was an iron spike driven in a crevice of a rock at the top of the hill. In the observations for horizontal intensity, July 8, the torsion was neglected, and in the computation the mean of the torsion of two sets taken on July 10 was used. This mean is probably not so great as it should be. The azimuth used in the observation for declination is the mean of four sets.

Results of observations at Godhavn.

	o ′
Dip (mean of 7 sets)	81 38.5
Declination (one set) W	66 26.5
Magnetic moment (mean of 4 sets)	0.447
Horizontal intensity (mean of 4 sets)	1.796

DIP.

Observations of July 8, 1883.

(Dip Circle No. 8. Needle No. 1.)

I.

[Time of beginning, 10.15 a. m. Time of ending, 10.45 a. m. Observer, Lamar.]

	Polarity of marked end N. (temp. 47°.5).			Polarity of marked end S. (temp. 47°.5).	
	Circle east.	Circle west.		Circle west.	Circle east.
	o ′	o ′		o ′	o ′
Face east, S	82 00.0	81 49.0	Face west, S	82 15.7	82 06.7
Face east, N	82 03.3	81 45.0	Face west, N	82 05.7	82 10.0
Mean	82 01.6	81 47.0	Mean	82 10.7	82 08.3
Face west, S	81 20.0	81 31.7	Face east, S	80 45.7	80 47.3
Face west, N	81 22.7	81 25.0	Face east, N	80 39.7	80 53.3
Mean	81 21.3	81 28.3	Mean	80 42.7	80 50.3
Mean, face east and face west with circle east	o ′ 81 41.4		Mean, face west and face east with circle west	o ′ 81 26.7	
Mean, face east and face west with circle west	81 37.6		Mean, face west and face east with circle east	81 29.3	
Mean, circle east and circle west	81 39.5		Mean, circle east and circle west	81 28.0	

Mean of polarities, circle east (marked end N) and circle west (marked end S)	81° 34′.0
Mean of polarities, circle west (marked end N) and circle east (marked end S)	81 33.4
Resulting dip	81 33.7

Circle in magnetic prime vertical:

		o ′
Circle N.	Needle N	14 21.0
	Needle S	13 28.0
Circle S.	Needle N	11 20.0
	Needle S	10 45.0
Magnetic meridian reads		12 28.5

II.

[Time of beginning, 11.5 a. m. Time of ending, 11.35 a. m. Observer, Ellis.]

	Polarity of marked end S (temp. 50°).			Polarity of marked end N (temp. 50°.8).	
	Circle east.	Circle west.		Circle west.	Circle east.
	° ′	° ′		° ′	° ′
Face east, S	80 33.8	81 02.0	Face west, S	81 58.8	81 45.0
Face east, N	80 35.0	80 57.8	Face west, N	81 35.0	81 44.3
Mean	80 34.2	80 59.6	Mean	81 46.6	81 44.6
Face west, S	81 44.0	82 45.0	Face east, S	82 11.7	81 48.3
Face west, N	81 47.3	82 40.0	Face east, N	82 05.7	81 58.3
Mean	81 45.6	82 42.5	Mean	82 08.7	81 53.2
	° ′			° ′	
Mean, face east and face west with circle east	81 09.9		Mean, face west and face east with circle west	81 57.6	
Mean, face east and face west with circle west	81 51.2		Mean, face west and face east with circle east	81 48.9	
Mean, circle east and circle west	81 30.6		Mean, circle east and circle west	81 53.2	

Mean of polarities, circle east (marked end S) and circle west (marked end N) ..... 81° 33′.8
Mean of polarities, circle west (marked end S) and circle east (marked end N) 81 50.0
Resulting dip 81 41.9

Circle in magnetic prime vertical:

		° ′
Circle N.	Needle N	11 16.0
	Needle S	22 05.0
Circle S.	Needle N	11 42.0
	Needle S	25 12.0

Magnetic meridian reads 17 33.8

III.

[Time of beginning, 12.25 p. m. Time of ending, 12.55 p. m. Observer, Ellis.]

	Polarity of marked end N. (temp. 59°).			Polarity of marked end S. (temp. 58°.9).	
	Circle east.	Circle west.		Circle west.	Circle east.
	° ′	° ′		° ′	° ′
Face east, S	81 51.7	81 58.3	Face west, S	82 23.0	82 00.0
Face east, N	81 52.3	81 57.6	Face west, N	82 16.0	82 03.0
Mean	81 52.0	81 58.0	Mean	82 19.5	82 01.5
Face west, S	81 49.3	81 38.0	Face east, S	81 06.0	80 33.3
Face west, N	81 49.3	81 35.0	Face east, N	80 56.7	80 38.3
Mean	81 49.3	81 36.5	Mean	81 01.4	80 35.8
	° ′			° ′	
Mean, face east and face west with circle east	81 50.6		Mean, face west and face east with circle west	81 40.4	
Mean, face east and face west with circle west	81 47.2		Mean, face west and face east with circle east	81 43.6	
Mean, circle east and circle west	81 48.9		Mean, circle east and circle west	81 44.5	

Mean of polarities, circle east (marked end N) and circle west (marked end S) ..... 81° 45′.5
Mean of polarities, circle west (marked end N) and circle east (marked end S) 81 47.9
Resulting dip 81 46.7

Circle in magnetic prime vertical:

		° ′
Circle N.	Needle N	63 55
	Needle S	62 50
Circle S.	Needle N	62 35
	Needle S	59 56

Magnetic meridian reads 62 19

HORIZONTAL INTENSITY.

Observations of July 8, 1883.

I.

[Deflections: Instrument, magnetometer No. 2. Magnet, T. V. 3, deflecting in magnetic prime vertical. Magnet, T. V. 4, suspended. Observer, Ellis.]

Magnet.	North end.	Time.	Temp. t.	Scale readings.	Alternate means.	Differences.
		h. m.	°			
West.	W.	7 30 p. m.	48.0	8.8		
	E.			140.0	7.50	132.50
	W.			6.2	139.45	133.25
	E.	7 36 p. m.		138.9		
						132.88
East.	E.	7 37 p. m.		140.0		
	W.			6.3	139.20	132.90
	E.			138.4	5.70	132.70
	W.	7 50 p. m.	47.0	5.1		
			47.5			132.80
Means.					$2u$	132.84

Distance: $r = 2.1$ feet. Log. $r = 0.32222$.

Computation: $\frac{m}{H} = \frac{1}{2} r^3 \tan. u \left(1 - \frac{P}{r^2} \ldots\ldots\right)$

	Logarithms.			Logarithms.
$v =$		$u =$	d. 66.42	1.82230
$5400' + v'$		1 division $=$	$2'.79$	0.44560
5400 (ar. co.)	6.26761	$1 + \frac{h}{f}$		0.00180
$1 + \frac{h}{f}$	0.00180	$u = 180'.08 = 3° 0'.08$		2.26970
			Tan. u	8.73385
			r^3	0.96666
			$\frac{1}{2}$	9.69897
			$\frac{m}{H}$	9.39948

OSCILLATIONS.

[Instrument, magnetometer No. 2. Magnet, T. V. 3. Chronometer, M. T. 5695. Daily rate, 1.0 s. losing on mean time. Observer, Ellis.]

Number of oscillations.	Chronometer time.	Temp. t'	Extreme scale readings.		Time of 60 oscillations.
	h. m. s.	°			m. s.
0	6 57 37.5	49.2	8	152	
6	58 58.5				
12	7 00 06.0				
18	01 21.0				
24	02 35.5				
30	03 49.5				
			32	142	
60	10 00.8				12 23.3
66	11 15.5				12 22.0
72	12 29.5				12 23.5
78	13 44.2				12 23.2
84	14 56.0				12 20.5
90	16 18.0	49.1	47	127	12 23.5
	Means.	49.2			12 22.667

[Coefficient of torsion. Value of one scale division = 2'.34.]

	Logarithms.
$v = 15'.0$	3.73351
$5400 + v'$	6.26761
5400 (ar. co.)	
$1 + \frac{h}{f}$	0.00112

COMPUTATION.

$$T^2 = T'^2 \left(1 + \frac{h}{f}\right) (1 - [t' - t]\, q)$$

	s.
Observed time of 60 oscillations	= 742.667
Time of 1 oscillation	= 12.3778
Correction for rate	= 0000
	T' = 12.3778

			Logarithms.
$t' - t$	0.00027	T'	1.09264
	+ 1.7		
$(t' - t)\, q$	0.00046	T'^2	2.18528
		$1 + \frac{h}{f}$	0.00112
$1 - (t' - t)\, q$	0.99954	$1 - (t' - t)\, q$	9.99980
		T^2	2.18620
$mH = \frac{\pi^2 K}{T^2}$ $m = 0.449$		(ar. co.) T^2	7.81380
$H = 1.784.$		π^2	0.99430
		K	1.09429
		mH	9.90239
		m	9.65094
		H	0.25145
		(*)	
		$\frac{m}{H}$	9.39948
		mH	9.90239
		m^2	9.30187
		m	9.65094

* Observations of deflections: Date, July 8. Hour, 7.30 p. m. Temp. $t = 47°.5$.

II.

[Deflections: Instrument, magnetometer No. 2. Magnet, T. V. 3, deflecting in magnetic prime vertical. Magnet, T. V. 4, suspended. Observer, Ellis.]

Magnet.	North end.	Time.	Temp. t.	Scale readings.	Alternate means.	Differences.
West.	W.	h. m.	46.0	26.9		
	E.			140.6	25.95	114.65
	W.			25.0	140.55	115.55
	E.			140.5		
		8 25 p. m.				115.10
East.	E.			143.6		
	W.			27.3	144.20	116.90
	E.			144.8	27.85	116.95
	W.		45.0	28.4		
						116.92
Means.			45.5		2 u	116.01

Distance: $r = 2.2$ feet. Log. $r = 0.34242$.

Computation: $\frac{m}{H} = \frac{1}{2} r^3 \tan u \left(1 - \frac{P}{r^3} \ldots\ldots\right)$

	Logarithms.			Logarithms.
$v =$		$u =$	d. 58.00	1.76343
$5400' + v'$		1 division =	2'.79	0.44560
5400 (ar. co.)	6.26761	$1 = \frac{h}{f}$		0.00180
$1 + \frac{h}{f}$	0.00180	$u = 162'.5 = 2° 42'.5$		2.21083
		Tan. u		8.67490
		r^3		1.02726
		$\frac{1}{2}$		9.69697
		$\frac{m}{H}$		9.40113

OSCILLATIONS.

[Instrument, magnetometer No. 2. Magnet, T. V. 3. Chronometer, M. T. 5695. Daily rate, 1.0 s. losing on mean time. Observer, Ellis.]

Number of oscillations.	Chronometer time.	Temp. t'	Extreme scale readings.		Time of 56 oscillations.
	h. m. s.	°			m. s.
0	7 56 59.5	49.0	22	152	
6	58 13.0				
12	59 27.5				
18	8 00 42.0				
24	01 55.5				
30	03 09.5				
56	8 08 29.0				11 29.5
62	09 43.6				11 30.6
68	10 58.0				11 30.5
74	12 11.5				11 29.5
80	13 25.5				11 30.0
86	14 39.5	48.0			11 30.0
	Means.	48.5			11 30.017

[Coefficient of torsion. Value of one scale division = 2'.34.]

	Logarithms.
$v = 15'$	3.73351
$5400 + v'$	6.26761
5400 (ar. co.)	
$1 + \frac{h}{f}$	0.00112

COMPUTATION.

$$T^2 = T'^2 \left(1 + \frac{k}{f}\right) (1 - [t' - t]\, q)$$

	s.
Observed time of 56 oscillations	= 690.017
Time of 1 oscillation	= 12.3218
Correction for rate	= 0.0000
T'	= 12.3218

			Logarithms.
q	0.00027	T'	1.09065
$t' - t$	+ 3.0	T'^2	2.18130
$(t' - t)\, q$	0.00081	$1 + \frac{k}{f}$	0.00112
$1 - (t' - t)\, q$	0.99919	$1 - (t' - t)\, q$	9.99965
		T^2	2.18207
$mH = \frac{\pi^2 K}{T^2}$ $m = 0.451$		(ar. co.) T^2	7.81793
		π^2	0.99430
$H = 1.789$		K	1.09428
		mH	9.90651
		m	9.65382
		H	0.25269
		*$\frac{m}{H}$	9.40113
		mH	9.90651
		m^2	9.30764
		m	9.65382

*Observations of deflections: Date, July 8. Hour, 8.25 p. m. Temp. $t = 45°.5$.

DIP.

Observations of July 9, 1883.

(Dip Circle No. 8. Needle No. 1.)

I.

[Time of beginning, 6 p. m. Time of ending, 6.15 p. m. Observer, Lamar.]

	Polarity of marked end S (temp. 59°).			Polarity of marked end N (temp. 57°).	
	Circle east.	Circle west.		Circle west.	Circle east.
	° ′	° ′		° ′	° ′
Face east, S	80 58.3	81 05.0	Face west, S	81 40.0	81 36.7
Face east, N	81 01.7	81 05.0	Face west, N	81 36.7	81 38.3
Mean	81 00.0	81 05.0	Mean	81 38.4	81 37.5
Face west, S	82 25.0	82 41.7	Face east, S	82 13.3	81 53.3
Face west, N	82 26.7	82 41.7	Face east, N	82 10.0	81 51.7
Mean	82 25.9	82 41.7	Mean	82 11.6	81 52.5
Mean, face east and face west with circle east	° ′ 81 42.9		Mean, face west and face east with circle west	° ′ 81 55.0	
Mean, face east and face west with circle west	81 53.4		Mean, face west and face east with circle east	81 45.0	
Mean, circle east and circle west	81 48.2		Mean circle east and circle west.	81 50.0	

	° ′
Mean of polarities, circle east (marked end S) and circle west (marked end N)	81 49.0
Mean of polarities, circle west (marked end S) and circle east (marked end N)	81 49.2
Resulting dip	81 49.1

Circle in magnetic prime vertical:

		° ′
Circle N.	Needle N	80 10
	Needle S	98 55
Circle S.	Needle N	80 17
	Needle S	96 00
Magnetic meridian reads		87 35.5

II.

[Time of beginning, 6.20 p. m. Time of ending, 6.35 p. m. Magnetic meridian reads, 87° 35′. Observer, Lamar.]

	Polarity of marked end N (temp. 55°).			Polarity of marked end S (temp. —).	
	Circle east.	Circle west.		Circle west.	Circle east.
	° ′	° ′		° ′	° ′
Face east, S	81 58.3	82 01.7	Face west, S	82 28.3	82 06.7
Face east, N	81 58.3	82 01.7	Face west, N	82 30.0	82 05.0
Mean	81 58.3	82 01.7	Mean	82 29.2	82 05.9
Face west, S	81 40.0	81 36.7	Face east, S	80 56.7	80 31.7
Face west, N	81 46.7	81 38.3	Face east, N	80 58.3	80 30.0
Mean	81 43.4	81 37.5	Mean	80 57.5	80 30.9
Mean, face east and face west with circle east	° ′ 81 50.9		Mean, face west and face east with circle west	° ′ 81 43.4	
Mean, face east and face west with circle west	81 49.6		Mean, face west and face east with circle east	81 18.4	
Mean, circle east and circle west	81 50.2		Mean, circle east and circle west	81 30.9	

	° ′
Mean of polarities, circle east (marked end N) and circle west (marked end S)	81 45.7
Mean of polarities, circle west (marked end N) and circle east (marked end S)	81 34.0
Resulting dip	81 40.6

DECLINATION.

(*Observation, July 9 and 10, 1883.*)

[Instrument, magnetometer No. 2. Magnet, T. V. 3, suspended, scale erect facing mag. N. Line of detorsion, 63°. Azimuth circle: A., 135° 53′; B., 315° 53′. Observers, Ellis and Lamar.]

Time, p. m.	Scale-readings. Left.	Right.	Mean.	Remarks.
h. m.	°	°	°	
4 00	60.0	72.0	66.0	Wind blowing so as to disturb the magnet considerably. The scale had been read frequently for an hour before commencing to record. The readings had been decreasing. Washington mean time.
4 15	57.2	66.0	61.6	
4 45	60.0	69.0	64.5	
5 15	69.0	69.0	69.0	
5 45	77.1	77.9	77.5	
6 05	87 2	88.4	87.8	
6 25	91.0	93.0	92.0	
6 45	90.0	92.0	91.0	
7 05	91.0	93.0	92.0	
7 25	82.0	85.0	83.5	
8 35	97.0	104.5	100.8	
9 35	96.1	99.9	98.0	
10 15	97.6	104.8	101.2	
11 00	118.6	121.5	120.0	
11 25	112.0	114.0	113.0	
LINE OF DETORSION, 40°.				
p. m.				
11 40	95.0	97.5	96.3	Increased readings on the scale correspond to decreased readings on the circle. Torsion weight suspended at 7.30 a. m., and torsion circle changed to 40°.
12 00	90.0	92.2	91.1	
a. m.				
12 30	92.3	91.0	91.6	
1 00	90.0	92.0	91.0	
9 45	61.9	65.3	63.6	
10 45	69.0	71.0	69.0	
11 35	74.1	75.5	74.8	
p. m.				
12 20	79.0	83.0	81.5	
12 45	90.4	95.0	92.7	
1 50	83.0	84.0	83.5	
2 30	88.8	90.0	89.4	
4 00	78.5	80.0	79.2	

COMPUTATION—READING OF MARK.

		° ′
At beginning of p. m. observations,	A	42 38
	B	222 38
At end of p. m. observations,	A	42 38
	B	222 39
Mean,		42 38.2

Determination of scale-value of magnet.				Determination of axis of magnet.					
Scale.	Circle readings, mean of verniers.		Value of 60 divisions.	Scale.	Scale readings.		Mean.	Alternate mean.	Axis.
	° ′ ″								°
10	140 17 00			E.	82.7	87.7	85.2		
20	139 54 00			I.	82.7	94.3	88.5	81.5	85.0
30	139 30 00			E.	74.5	81.0	77.8	89.0	83.4
40	139 06 00			I.	88.0	91.0	89.5	79.6	84.6
50	138 42 00			E.	76.0	86.7	81.4	88.3	84.9
60	138 18 00			I.	84.0	90.0	87.0	82.8	84.9
70	137 57 00		2° 20′ 00″	E.	82.5	85.9	84.2	86.4	85.3
80	137 32 00		2 22 00	I.	84.6	87.0	85.8	86.0	85.9
90	137 09 00		2 21 00	E.	82.2	93.2	87.7	82.9	85.3
100	136 46 00		2 20 00	I.	80.1	83.7	81.9	89.4	85.6
110	136 22 00		2 19 00	E.	88.0	94.0	91.0		
120	135 59 00		2 19 00	I.					
130	135 35 00		2 22 00						
140	135 11 00		2 21 00						
150	134 49 00		2 20 00						
160	134 25 00		2 21 00						
Value of 1 division of scale = 2′.341.				Scale reading of axis.					85.0
Mean scale reading of east and west magnetic elongation:									90.8
							=diff.=		5.8

	° ′
Reduction to axis,	13.6
Azimuth circle reads,	135 53.0
Magnetic N meridian reads,	135 39.4
Mean reading of mark,	42 38.2
Azimuth of mark W of N,	159 27.8
True meridian reads N,	202 06.0
Magnetic declination W,	66 26.6

HORIZONTAL INTENSITY.

Observations of July 10, 1883.

I.

[Deflections: Instrument, magnetometer No. 2. Magnet, T. V. 3, deflecting in magnetic prime vertical. Magnet, T. V. 4, suspended. Observer, aLmar.]

Magnet.	North end.	Time, p. m.	Temp. t.	Scale readings.	Alternate means.	Differences.
		h. m.	°			
West.	W.	7 20	48.0	14.90		
	E.			145.50	14.58	130.92
	W.			14.25	145.50	131.25
	E.	7 35	47.5	145.50		
						131.09
East.	E.	7 40	47.5	138.40		
	W.			8.60	137.65	129.05
	E.			136.90	8.55	128.35
	W.	7 50		8.50		
						128.70
Means.			47.7		$2u$	129.90

Dist., $r = 2.1$ feet. Log. $r = 0.32222$

Computation: $\frac{m}{H} = \frac{1}{2} r^3 \tan u \left(1 - \frac{P}{r^2} \ldots\ldots\right)$

Tors. cir.	Scale.		Mean.	Diff's.		Logarithms.		Logarithms.
							d.	
40	68.0	62.9	65.4		$v =$ 20′.8		$u =$ 64.95	1.81258
				5.2	5400′ + v'	3.73406	1 div'n = 2′.79	0.44560
65	62.1	79.2	70.6		5400 (ar. co.)	6.26761	$1 + \frac{h}{f}$	0.00167
				21.4				
15	38.4	60.0	49.2		$1 + \frac{h}{f}$	0.00167		2.25985
				3.3			$u =$ 181′.91	
40	56.2	49.0	52.5				= 3° 01′.9	
							Tan. u	8.72396
							r^3	0.96636
Mean $v = 7.47$							$\frac{1}{2}$	9.69897
							$\frac{m}{H}$	9.38959

OSCILLATIONS.

[Instrument, magnetometer No. 2. Magnet, T. V. 3. Mass ring, —. Chronometer, M. T. 5695, daily rate 1.0 S. losing on mean time. Observer, Lamar.]

Number of oscillations.	Chronometer time.	Temp. t'.	Extreme scale readings.		Time of 60 oscillations.
	h. m. s.	°			m. s.
0	6 35 39.1	50.0	20.0	148.0	
6	36 53.2				
12	38 06.9				
18	39 21.1				
24	40 34.2				
30	41 48.4				
		53.0			
60	47 58.0				12 18.9
66	49 12.2				12 19.0
72	50 26.0				12 19.1
78	51 40.0				12 18.9
84	52 53.6				12 19.4
90	54 07.7	50.0	43.0	119.0	12 19.3
	Means.	51.0			12 19.1

[Coefficient of torsion: Value of one scale division = 2'. 34.]

Tors. circle.	Scale.		Mean.	Differences.		Logarithms.
40	75. 5	83. 8	79. 6	6. 8	$v = 14'.7$	
65	77. 0	95. 8	86. 4	12. 0	$5400' + v'$	3. 73358
15	65. 9	82. 8	74. 4	6. 4	5400 (ar. co.)	6. 26761
40	67. 5	94. 0	80. 8		$1 + \frac{k}{f}$	0. 00119
Mean $v = 6.3$						

COMPUTATION.

$$T^2 = T'^2 \left(1 + \frac{k}{f}\right) (1 - [t' - t]\, q)$$

	s.
Observed time of 60 oscillations	= 739. 1
Time of 1 oscillation	= 12. 318
Correction for rate	= 0. 000
T'	= 12. 318

			Logarithms.
q	0. 00027	T'	1. 09054
$t' - t$	3. 3	T'^2	2. 18108
$(t' - t)\, q$	0. 00089	$1 + \frac{k}{f}$	0. 00119
$1 - (t' - t)\, q$	0. 99911	$1 - (t' - t)\, q$	9. 99961
		T^2	2. 18188
$mH = \frac{\pi^2 K}{T^2}$ $\quad m = 0.445$		(ar. co.) T^2	7. 81812
		π^2	0. 99430
$H = 1.817$		K	1. 09430
		mH	9. 90672
		m	9. 64816
		H	0. 25856
		$\frac{m}{H}$	9. 38959
		mH	9. 90672
		m^2	9. 29631
		m	9. 64816

* Observations of deflections: Date, July 10. Hour, 7.30 p. m. Temp. $t = 47°.7$.

II.

[Deflections: Instrument, magnetometer No. 2. Magnet, T. V. 3, deflecting in magnetic prime vertical. Magnet, T. V. 4, suspended. Observer, Ellis.]

Magnet.	North end.	Time.	Temp. t.	Scale readings.	Alternate means.	Differences.
		h. m.	°			
West.	W.	9 10 p. m.	46. 5	12. 20		
	E.			124. 50	11. 35	113. 15
	W.			10. 50	124. 50	114. 00
	E.			124. 50		
						113. 58
East.	E.			127. 75		
	W.			14. 70	128. 88	114. 18
	E.			130. 00	14. 60	115. 40
	W.	9 30 p. m.	46. 5	14. 50		
						114. 79
Means.			46. 5		$2u$	114. 18

$r = 2.2$ feet. Log. $r = 0.34242$.

Computation: $\frac{m}{H} = \frac{1}{2} r^3 \tan. u \left(1 - \frac{P}{r^3} \ldots\ldots\right)$

Tors. cir.	Scale.		Mean.	Differences.
40	70.0	72.2	71.1	
				8.8
65	72.4	87.4	79.9	
				16.9
15	40.0	86.0	63.0	
				8.6
40	41.3	102.0	71.6	

Mean $v = 8.6$.

	Logarithms.
$v = 24.0$	
$5400' + v'$	3.73432
5400 (ar. co.)	6.26761
$1 + \frac{h}{f}$	0.00193

d.
$u = 57.09$
1 division $= 2'.79$
$1 + \frac{h}{f}$
$u = 159'.99 = 2° 40'.0$

	Logarithms.
	1.75656
	0.44560
	0.00193
	2.20409
Tan. u	8.66816
r^3	1.02726
$\frac{1}{2}$	9.69897
$\frac{m}{H}$	9.39439

OSCILLATIONS.

[Instrument, magnetometer No. 2. Magnet, T. V. 3. Chronometer, M. T. 5695. Daily rate, 1.0 S. losing on mean time. Observer, Ellis.]

Number of oscillations.	Chronometer time.	Temp. t'	Extreme scale readings.		Time of 60 oscillations.
	h. m. s.	°			m. s.
0	9 49 46.2	46.3	19	141	
6	51 00.4				
12	52 14.2				
18	53 28.6				
24	54 42.7				
30	55 56.8				
		46.0			
60	10 02 07.6				12 21.4
66	03 21.8				12 21.4
72	04 36.1				12 21.9
78	05 51.0				12 22.4
84	07 05.2				12 22.5
90	08 19.5	47.0	36	123	12 22.7
	Means.	46.4			12 22.05

[Coefficient of torsion. Value of one scale division $= 2'.34$.]

Tors. circle.	Scale.		Mean.	Diff's.
40	78.0	80.0	79.0	
				6.4
65	80.0	90.9	85.4	
				13.4
15	58.0	86.0	72.0	
				6.4
40	60.8	96.0	78.4	

Mean $v = 6.55$

$v = 15'.3$
$5400' + v'$
5400 (ar. co.)
$1 + \frac{h}{f}$

Logarithms.
3.73363
6.26761
0.00104

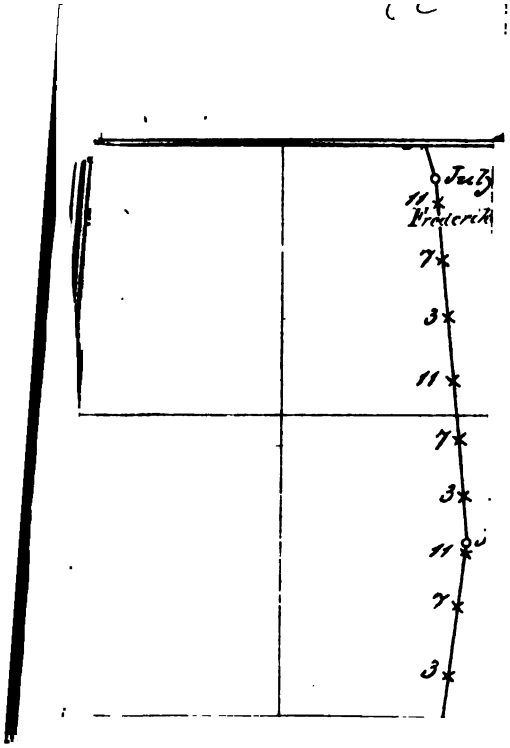
COMPUTATION.

$$T^2 = T'^2 \left(1 + \frac{h}{f}\right) (1 - [t' - t]\, q)$$

	s.
Observed time of 60 oscillations	= 742.05
Time of 1 oscillation	= 12.3675
Correction for rate	= 0.0000
	T' = 12.3675

			Logarithms.
q	0.00027	T'	1.09227
$t' - t$	−1°.1	T'^2	2.18454
$(t' - t)\, q$	0.00003	$1 + \frac{h}{f}$	0.00104
$1 - (t' - t)\, q$	1.00003	$1 - (t' - t)\, q$	0.00000
		T^2	2.18558
$mH = \frac{\pi^2 K}{T^2}$ $\quad m = 0.445$		(ar. co.) T^2	7.81442
		π^2	0.99430
$H = 1.796$		K	1.09427
		mH	9.90299
		m	9.64869
		H	0.25430
		*m	
		H	9.39439
		mH	9.90299
		m^2	9.29738
		m	9.64869

* Observations of deflections: Date, July 10. Hour, 9.20 p. m. Temp. $t = 46°.5$.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SIGNAL OFFICE, WAR DEPARTMENT.

SIGNAL SERVICE NOTES NO. XV.

DANGER LINES AND RIVER FLOODS

OF 1882.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY,

BY

H. A. HAZEN,
JUNIOR PROFESSOR, O. C. S. O.

Reprinted, with additions, from Annual Report of Chief Signal Officer, 1882.

BY AUTHORITY OF THE SECRETARY OF WAR.

WASHINGTON CITY:
SIGNAL OFFICE.
1884.

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1884.

REVISION OF THE DANGER LINES OF MARCH 15, 1875.

WAR DEPARTMENT,
OFFICE OF THE CHIEF SIGNAL OFFICER,
Washington, D. C., August 19, 1882.

The CHIEF SIGNAL OFFICER:

SIR: I have the honor to state that the work on the revision of the circular of March 15, 1875, relative to danger lines, having been entrusted to Mr. H. A. Hazen, I have also, therefore, given him the work on the cognate subject, namely, the compilation of the reports relative to the floods of March, 1882, which latter was recently transferred from the Fact Room to the Study Room. As the latter work presupposes the completion of the former, I have the honor to present the following report thereon in anticipation of the completion of both works.

Very respectfully,

CLEVELAND ABBE,
Professor and Assistant, O. C. S. O.

THE REVISION OF THE CIRCULAR ON DANGER LINES, DATED MARCH 15, 1875.

The accompanying order No. 48, of June 27, 1881, was prepared by Lieut. A. W. Greely, and this report is made from the replies to this order. Many delays have occurred in the issue of this revision owing to defective replies and neglect on the part of observers in delaying answers. Several of the stations have not yet replied, though every effort has been put forth to obtain replies. I have arranged, 1, in a convenient form for reference, all the essential points relating to river gauges; 2, as the information relating to danger lines seemed of great importance, there is given nearly a complete copy of the observers' notes relating thereto; 3 tables of highest and lowest waters are given.

It should be borne in mind that, as no expense was provided for in determining levels, many of the elevations herein given are only approximate; this is especially so in regard to the elevations above sea of all gauges, except those at regular Signal Service meteorological stations.

The work of compilation has been done by—

H. A. HAZEN,
Computer, O. C. S. O.

[Signal Service Orders No. 48.]

WAR DEPARTMENT,
OFFICE OF THE CHIEF SIGNAL OFFICER,
Washington, D. C., June 27, 1881.

The following reports will be prepared and forwarded, without unnecessary delay, to this office from all river stations:

First. Report what low-water or other stage of the river is adopted as the zero of the station-gauge, *and why this was assumed*, with a statement of the corresponding depths of water in the channel or on the bars, which were used as reference points at that station in the establishment of the zero point.

Second. State whether the river gauges at your station are estimated in feet and inches, in feet and hundredths (or whatever the system of notation on the scale).

Third. A statement of the readings of station river-gauges for highest and lowest water of each year, with the respective dates, since the station was established. If the station-gauge was in use before the Signal Service station was established, give these data, as far back as attainable, with name of observer.

Fourth. A statement of the readings of any other river-gauges by whomsoever kept in the immediate vicinity of the station, giving the highest and lowest water for each year, with the name of person who kept the record. If such record has been kept simultaneously with that of the regular station, state, by the mean of at least ten simultaneous readings during some period of low water, the comparative zero of the two gauges.

Fifth. For records of similar data not now accessible at the station, state by whom and for what periods kept, and if accessible elsewhere, in whose possession and where at the present time.

Sixth. A statement of the horizontal distance along the river channel, in miles and feet, of all gauges from the station-gauge, and whether up or down stream; this statement to cover all the gauges reported upon under the second and fourth heads of this order.

Seventh. A statement of the reading on the station-gauge corresponding to the beginning of "Danger," the nature of the danger, and at what reading it is extensively threatened.

Eighth. Report in detail, so far as it can be accurately ascertained, the differences of level, in feet and inches, between the zeros of all the gauges and the following points, viz: 1, the beds of railroad tracks at all the neighboring depots; 2, the bench-marks of canals; 3, the planes of reference adopted by the city or town engineers in their surveys; 4, the cistern of the Signal Service barometer at the station.

Ninth. Report upon any well-defined and well-authenticated marks now existing, showing the height attained by special floods and low waters not otherwise recorded on the station-gauge, or which exceeded its extreme limits. State what these extreme high or low water marks would be relatively to the zero of the station-gauge, if these data can be furnished without the cost of running levels, and what extension of the station-gauge is necessary to cover these extreme cases.

Tenth. Give any additional information or explanation of the foregoing that may be useful in revising and extending the circular on Danger Lines, dated March 15, 1875 (see Annual Report of Chief Signal Officer, 1875, pp. 357–361), and Special Reports of Lieut. A. W. Greely (Annual Report of Chief Signal Officer, 1874, pp. 312–322). Thus, every change in the elevation of the gauges, or of the zeros of any of these gauges, should be noted, and the exact extent and date of the change reported. The building of bridges, dams, canals, or other obstructions, or their removal if sufficient to retard or impede the flow of the river, and thus affect the height of water on the gauges, should be noted, with the date of such changes. These reports are not to involve increased expenses at any station, and no expenses will be approved which have not been estimated for, and approved and ordered from this office before they were undertaken.

By order of the Chief Signal Officer.

LOUIS V. CAZIARC,

1st Lieutenant 2d Artillery, Acting Signal Officer.

Revision of the circular of March 15, 1875, on danger lines at Signal Service river stations.

Station.	Zero of gauge.	Highest water.	Danger line.		Height of zero.			Remarks.
					Below railroad track at—	Below S. S. bar.	Above sea.	
			Beginning. ′ ″		′ ″	′ ″	′	
Augusta, Ga	Low water, 1835	37′ 10″, 1840	32 6	At 37′ the entire city would be flooded. At 35′ nearly one-half of the city would be flooded.	Union depot	31 4	54 1	129	
Boonville, Mo	Low water, Dec. 1, 1872.	33′ 7″, 1844	20 0	At 23′ Old Franklin across the river would be flooded.	Missouri Pacific depot	38 6		547	High water of 1844 is located by a stone at the foot of Main street.
Brownsville, Pa	5′ above river bed.	36′, April, 1852	25 0	At 30′ danger is extensively threatened.					
Brunswick, Mo	Low water, Feb. 6, 1876.	31′, 1844	16 0	At this height many cultivated farms are flooded.	Wabash, Saint Louis and Pacific.	32 0		628	Zero of gauge was placed 5′ lower on July 1, 1881. This is low water of February 6, 1876.
Cairo, Ill	Low water, Oct. 25, 1871.	52′ 2″, Feb. 26, 1883.	40 0	At 51′ 4″ water would overflow the levee and flood the city.	Illinois Central	51 3	86 5	290	
Chattanooga, Tenn	Low water, Sept., 1839.	56′ $\frac{5}{8}$″, 1867	33 0	At 38′ many dwellings are flooded.	Union depot	49 9	152 0	621	
Cincinnati, Ohio	2′ 4″ below low water, 1858.	71′ $\frac{3}{4}$″, Feb. 14, 1884.	50 0	Dangerous to navigation in very high or low water.	Ohio and Mississippi	55 4	189 9	430	
Confluence, Pa	1′ above bed of river.	13′ 6″, Aug., 1875	10 0	At 11′ 5″ water runs into some houses and damages property on banks.	Baltimore and Ohio	22 0		1,322	
Davenport, Iowa	.34′ below low water, 1864.	20′ 6″, Mar., 1868	15 0	This would endanger property in lower part of Rock Island and Muscatine.	Chicago, Rock Island and Pacific.	49 2	70 5	545	
Decatur, Ala	Low water, Oct., 1878.	28′, 1867	20 0		Memphis and Charleston	36 2		537	
Dubuque, Iowa	Low water, 1864	22′ 8″, June 23, 1860.	16 0		Chicago, Milwaukee and Saint Paul.	21 7	80 6	584	At low water all bars are exposed from 6″ to 5′.
Eugene City, Oreg	11′ above river bed.	24′, 1861 and 1862	10 0	This endangers stock on bottom lands and merchandise on lower wharves.				457	Zero corresponds to a depth of 3′ on bars.
Evansville, Ind	Low water, 1867	46′, 1832	None	Grade of city is 48′ 2″ above zero. At 36′ bottoms above and below are endangered.	From	50 to 55		320	

Revision of the circular of March 15, 1875, *on danger lines at Signal Service river stations*—Continued.

Station.	Zero of gauge.	Highest water.	Danger line.		Height of zero.			Remarks.
					Below railroad track at—	Below S. S. bar.	Above sea.	
			Beginning.					
			′ ″		′ ″	′ ″	′ ″	
Folsom City, Cal.	Low water, 1876 or 1877.	42′, Jan., 1861	35 0				200(?)	
Fort Smith, Ark.	7′ above low water.	23′, Jan., 1868	15 0	At 20′ the bottoms are flooded, destroying crops, cattle, &c.	24		436(?)	There would seem to be a cycle in the flow of the river of seven or eight years. High water, 1844, 1852, 1859, 1868, and 1878. Low water, 1847, 1856, 1863, 1871, 1879, 1880, and 1881.
Freeport, Pa.	Low water, 1868	34′, 1882	20 0		Track on bridge 31 0		741	Zero represents 1′.5 on the "Dock Riffle," one mile above gauge.
Helena, Ark.	Low water, 1872	46′ 5″, 1862	37 to 38 0	At 44′ the levees are endangered.	Abt. 47 0		150(?)	Zero gives about 4′ on bars.
Hermann, Mo.	Low water, Dec., 1878.	24′ 7″, May, 1881	21 0		34 0		abt. 477	
Jefferson City, Mo.	Low water, 1867	Over Water st., 1844.	20 0	This floods bottoms of Calloway county, opposite.	Missouri Pacific track 28 5		528	Gauge is very liable to be washed away.
Kansas City, Mo.	1′ 6″ below low water, Dec. 2, 1874.	37′, 1844	21 0				734	
Keokuk, Iowa	Low water, Dec., 1873.	21′ 6″, 1851	14 6		Track foot of Main st. 27 3	142 7	475	Zero gives 16″ water on Des Moines rapids.
La Crosse, Wis.	Low water, Oct., 1871.	15′ 2″, June 19, 1880.	24 0	This would flood lower part of the city. No dangerous rise has ever occurred here.	Milwaukee and Saint Paul. 23 8	82 0	643(?)	Zero gives about 2′ of water in channel.
Leavenworth, Kans.	Low water, Nov., 1871.	25′ 10″, Apr. 29 1881.	20 0		Union Depot 26 5	88 8	753	
Le Claire, Iowa	Low water, 1864	14′ 6″, June 25, 1880.	10 0	This begins to overflow bottoms of Wapsipinicon river, 10 miles above here.			abt. 545	
Little Rock, Ark.	9″ above low water, Oct., 1879.	31′, 1844	23 0	This floods low lands; at 26′ danger is extensively threatened.	Iron Mountain 38 0	85 1	213	

Louisville, Ky	Sill of lock of canal.	46′ 7″, Feb. 15, 1884.	25 0	Damage slight at this mark.	Ohio and Mississippi	52 9	147 2	383	Since extension of the dam the readings are not comparable with those before.
Marysville, Cal	River bed		15 0	Dangerous to levees		abt. 7 3		Abt. 60	
Memphis, Tenn	1′ above low water, Dec. 25, 1872.	35′ 7″, Feb. 28, 1883.	34 0		Louisville and Nashville	42 8	134 6	186	0′.95 has been added to gauge readings since May 6, 1881.
Morgantown, W. Va	River bed	1852	20 0	Dangerous to navigation. No special danger till 28′ to 30′ is reached.			173 0	790	Water slacked very little, if any, by the dam.
Nashville, Tenn	Low water, Aug., 1860. July 1, 1884, gauge changed to engineer's. Zero is low water of September, 1863, five inches higher than before.	55′ 2″, 1847	40 0				313 8	193 0	Depth of channel at gauge, 12′.
New Geneva, Pa	River bed	40′ 0″, 1852	18 0	Impedes navigation and endangers mill property by back water.					Sudden rises are generally from Cheat river.
New Orleans, La	High water, Apr. 16, 1874.	Zero, April, 1874	— 3 0		New Orleans and Mobile	1 9½	41 2.5	14 8	
Oil City, Pa	6″ above low water, Sept., 1880	21′ 0″, Mar. 17, 1865.	13 0	At 20′ some of the streets are flooded and two bridges are endangered.				1,000 0 (abt.)	Zero of gauge gives no water on Charley's riffle, the shallowest point between Oil City and Pittsburg.
Omaha, Nebr	Low water, 1867	23′ 9½″, Apr. 25, 1881.	18 0		Union Pacific	72 0	130 0	983 0	
Oroville, Cal	Lowest water known.		10 0	Threatens danger to Marysville and country below Oroville.					Channel is continually shifting and changing.
Paducah, Ky	Low water, 1857	53′ 0″, 1867	40 0						
Pittsburg, Pa	Log, foot of Market street.	35′ 0″, Feb., 1832	22 0	A sudden rise above 18′ would endanger navigation.	Union depot	43 5	67 8	694 0	Dam at Davis's Island affects the water at this gauge.
Plattsmouth, Nebr	Low water, Dec. 6, 1873.	19′ 3″, Apr. 25, 1881.	16 7		B. and M. R.	27 1		906 9	
Port Eads, La	2′ 9″ below mean flood-tide.	4′ 4″, Oct. 1, 1877		No danger line			9 3		Depth of channel in South Pass, in front of station, is 32′ when gauge reads 2′ 9″.
Portland, Oreg	Low water, 1867	28′ 2″, June 24, 1876.	15 0	This floods lower docks, and at 26′ the upper docks are flooded.			66 5		There is a tide of 1′ 6″ during low water.
Red Bluff, Cal	Low water, 1876	28′ 6″, Feb. 4, 1851	20 0	At 22′ bottoms are flooded		62 0	80 5	266 0	Depth of water on bars at zero from 2′ to 4′.

Revision of the circular of March 15, 1875, *on danger lines at Signal Service river stations*—Continued.

Station.	Zero of gauge.	Highest water.	Danger line.		Height of zero.			Remarks.
					Below railroad track at—	Below S. S. bar.	Above sea.	
			Beginning. ′ ″		′ ″	′ ″	′ ″	
Sacramento, Cal.	Low water, Sept. 1, 1849.	26′ 6″, Feb. 4, 1861.	25 0	Dangerous to levees within 20 miles of this city.	Central Pacific	29 0	65 0	5 0	If levee breaks on opposite side it relieves this.
Saint Louis, Mo.	Low water, Dec. 21, 1863.	41′ 5″, June 27, 1844.	32 0				173 2	395 0	Water at zero has a depth in channel of from 30′ to 36′.
Saint Paul, Minn.	Low water, Sept. 5–13, 1877.	19′ 8″, Apr. 29, 1881	7 0	Above 14′ danger is extensively threatened.	Chicago, Milwaukee and Saint Paul.	22 3	137 7	673 0	The zero of this gauge is involved in some confusion.
Umatilla, Oreg.	Low water, Mar., 1874.	30′ 0″, June, 1876.	31 0	32′ would be dangerous to the town; 30′ caused great danger 100 miles below.			38 2	262 0	
Vicksburg, Miss.	Low water, 1871.	52′ 10″, 1864	41 0	Danger is chiefly along the Louisiana side. No danger to Vicksburg, which is on the bluffs.			190 3	54 0	
Warsaw, Ill.	3 feet above river bed.	21′ 5″, 1851	12 0					abt. 475 0	
Yankton, Dak.	Bed of river	30′ 0″, Feb., 1868.	24 0		Railroad	23 6	51 8	1,176 0	

ADDITIONAL NOTES RELATING TO DANGER LINES.

AUGUSTA, GA.

The peculiar topography of the country surrounding this city renders it very liable to overflow, and nearly every year grave apprehensions are felt. About 1½ miles above the river gauge a natural hollow, known as Hawk's Gully, exists, and by this channel the water first enters the city; and the danger is also increased by its near proximity to the Augusta Canal, and the probability of crevasses being formed in the embankment of the same. About a mile below the river gauge the river bends sharply to the southeast; and here a thick growth of trees and underbrush, by obstructing to a certain extent the flow of water, causes it to back up towards the city.

CAIRO, ILL.

At 46 feet all the lowland between Cairo and Memphis, on the Kentucky and Tennessee side, is inundated, and in some places the expanse of water is 30 miles or more in width, and the only grounds above water are those surrounding the Chickasaw Bluffs, which are at intervals between Cairo and Memphis.

Danger is extensively threatened at 49 feet, when the water flows over the banks in many places and inundates the country for many miles on both sides of the river; at 51 feet 4 inches on gauge, the water would overflow the top of Cairo levee and submerge the entire city.

CHATTANOOGA, TENN.

Danger line begins at 33 feet upon the gauge, at which height the low grounds in south Chattanooga are submerged, but there is no apprehension till 38 feet is reached, when various dwellings and manufacturing establishments begin to be flooded and communication with the surrounding country by roads interrupted. The Tennessee is subject to very rapid rises from heavy rainfall in the mountains, constituting the rim of its basin. In twenty-four hours, September 15–16, 1878, the water rose almost perpendicularly from 9 inches to 10 feet 7 inches on the gauge, with no rain here. In cases of both the disastrous floods of 1867 and 1875 there had been a great previous accumulation of snow in the mountains of Virginia, North Carolina, and Tennessee, which, suddenly melting, and combined with very heavy rainfall, resulted in great damage to this valley.

Supplementary to the fully appreciated warning afforded by the Signal Service, the Coal, Iron, and Manufacturers' Association of this city, in 1880, appointed a committee on flood signals, of which Rev. J. W. Bachman is chairman, who have, since June, 1880, organized and kept up a system of reports from voluntary observers, at twenty points on the river above, embracing the entire drainage system of the Tennessee in Virginia, North Carolina, and this state, with marked beneficial results to the community.

DECATUR, ALA.

Danger is at 20 feet, at which height the water overflows all lowlands adjacent, destroys crops and often stock, which may be overtaken far from mounds or high places. The island in the river often suffers worse than and earlier than the mainland. At 22 feet and 23 feet the danger is still greater, as the mounds are covered, and stock is liable to be drowned or starved unless rescued.

The highest water ever known here was 28 feet above zero, in 1867, and is marked on bridge pier where the gauge is secured; great damage was done to stock, buildings, hay and fodder stacks, &c.

DUBUQUE, IOWA.

At 16 feet the water floods islands and bottom lands; at 18 feet the lower floors of houses on flats are covered; at 20 feet all saw-mills must close, the levee is flooded,

two plow-works, three iron-works, and one oil-mill would have to stop, and danger would be extensively threatened; at 21 feet the main tracks and depots of the Chicago, Milwaukee and Saint Paul Railroad and the Illinois Central Railroad are 6 feet under water, and travel greatly obstructed. No farms or bottom lands within 5 miles of the city.

HERMANN, MO.

The reading of the water gauge corresponding to the beginning of danger is supposed to be 21 feet above low water of 1878, this being the height at which the river begins to overflow its lowest banks; at 25 feet it enters the higher bottom or farming lands, and danger is then extensively threatened.

KANSAS CITY, MO.

The danger line is 21 feet above zero. The nature of the danger would be the overflowing of the bottoms opposite the city; at 23 feet danger would be extensively threatened, and the water would overflow parts of western portion of city, known as West Kansas City. This portion of the city is densely populated, contains large elevators, machine shops, packing houses, wholesale houses, stock yards, Union depot, and several railroad freight depots. During the high water of 1881 several of the railroad tracks through this portion of the city were under water as much as 3 feet, depending on the surface of the ground.

KEOKUK, IOWA.

Danger line is 14 feet 6 inches on Signal Service gauge; above this line the Keokuk and Saint Louis railroad and bottom lands lying south of the mouth of the Des Moines river are threatened. The Des Moines river empties into the Mississippi about 2½ miles below this city, and floods are greatly influenced by the stage of water in the Des Moines river, backing up the Mississippi.

LEAVENWORTH, KANS.

Danger begins at a stage of water corresponding to 19 feet on the station gauge, by submerging the railroad tracks at Oak Mills, 11 miles north of the city. At 20 feet the farms on the lowlands are overflowed, and nearly 2 feet of water is on the railroad tracks in several places, both north and south of the city.

MEMPHIS, TENN.

The present danger line is at 34 feet. The Arkansas shore opposite, and Tennessee shore above and below are inundated in many places when river gauge reads 33 feet 6 inches, as recorded in the station daily journal, March 2, 1880. Superintendent Smith, of the Little Rock and Memphis railroad, says that when gauge reads 32 feet the river overflows in many places and makes connection with Four-Mile Bayou distant 5 miles.

The depression caused by the earthquake of 1811 at New Madrid, Mo., and vicinity, it is believed, allows the Mississippi passage to the Saint Francis river basin, which it reaches with inundation when the gauge is 30. (See Report Secretary of War, 1871, part 2, pp. 356–358.) At 30 feet life and property are threatened at Bradley's Landing, Ark. In the foregoing, gauge readings given are those published as reduced to low water of December 25, 1872.

NASHVILLE, TENN.

No damage is anticipated under 39 or 40 feet. At a height of 30 feet the lowlands in the northern portion of the city become flooded, slightly impeding travel, but not overflowing houses. On opposite bank of river, in East Nashville, the land is much lower than here. With a reading of 42 feet buildings are greatly endangered; any rise over 1 foot per hour is dangerous to goods along the bank.

NEW ORLEANS, LA.

Records in this office show that with a reading of minus 3 feet 8 inches on gauge there is danger of crevasses being formed both above and below gauges.

The danger line has been placed at different stages: In 1872 at minus 3 feet; some time after this it was placed at minus 2 feet 5 inches. (Report of Chief Signal Officer for 1874, page 316.) Again, it was placed at minus 2 feet 8 inches and minus 3 feet 8 inches, and finally, in 1875, it was placed at minus 1 foot 5 inches. At all the above stages it is reported as creating great alarm; Belle Chasse, Greenwood, and Point La Hache crevasses did not occur until the reading of the gauge was minus 0 feet 4 inches.

As crevasses may occur at stages between 4 feet and zero, it would appear that the formation of crevasses depends more on the condition of the levees than the stage of water in the river. There is little danger from an overflow of banks; the danger lies in the bad condition of the levees. In the great floods of the spring of 1881 the eastern rivers sent out great volumes of water earlier than the western, and the gauge read no higher than minus 2 feet 2 inches.

Reading of gauge at time of crevasses,

Date.	Reading.	Crevasses.
	′ ″	
January 30, 1880	—3 2	At Caseborne, 5 miles from city; quickly stopped.
February 6, 1880	—3 4	At Kemerer, 15 to 200 feet wide; no great damage.
March 7, 1880	—2 4	At Lockport, 34 feet 6 inches wide; slight damage.
April 1, 1880	—1 7	At south side of river, 4 miles above Algiers, 10 feet wide, 8 feet deep; on the 2d, increased and several plantations were submerged.
April 20, 1880	—0 11	No crevasse.
April 8, 1881	—2 2	Do.

Fears are entertained when the gauge indicates minus 2 feet; at this stage, with high waters in the north and east rivers, the levees are strengthened at the weakest point and everything held in readiness in the event of a break occurring.

OMAHA, NEBR.

General overflow begins at about 18 feet; Union Pacific Railroad shops and smelting-works are flooded at about 20 feet; then danger is extensively threatened; water will begin to cover the tracks and bridges near the Union Pacific transfer depot, and any further rise will suspend all railroad business, inundating tracks and railroad buildings, the stock yards, and submerging all the lower portion of Council Bluffs, Iowa, and Omaha.

PLATTSMOUTH, NEBR.

Sixteen feet 7 inches endangers farms on east side of river. During the high water of April, 1881, the water at 16 feet backed up over thousands of acres of low grounds. As it went on upward it flooded the entire bottom (5 miles wide), and drove all the residents, with stock and goods, out. At 16 feet also it began cutting on the railroad embankments, as also on the river bank 1½ miles above Plattsmouth (but on the east side of the river), at a dangerously low place (embanked and riprapped by the railroad company to protect it). At 16 feet the water broke through this and swept down through the bottoms, taking embankments and defenses in the rear, and causing very great damage (talk of from $100,000 to $500,000). To the residents of the bottom the old line, 16 feet 7 inches, is not far from danger. The railroad company is raising and stengthening their defenses to a higher point.

SAINT LOUIS, MO.

The city directrix is 33.8 feet above the zero of gauge, and is located opposite No.

4 South Front street. It is the high-water mark of 1826, established by Col. R. Paul, city surveyor, and approved by the board of aldermen for that year. This point is a few yards below Market street. The latter runs perpendicularly to the river bank east and west, dividing the city into two portions, nearly equal before the incorporation of Carondelet with the city of Saint Louis proper. The central *business* portion of the city extends nearly equal distances north and south of Market street. Plum street is its southern, Cherry street its northern terminus along the levee, which between these points is nearly on a level with the city directrix. For this portion of the city I would designate any rise in the river above 39 feet as the "danger line." More than half the houses along the levee, at this state of water, would be flooded to a greater or less extent, and all the merchandize on the levee would be submerged or washed away.

The extreme northern and southern portions of the city, however, are exposed to danger at a stage of water much lower than that above indicated; most of this territory would be threatened by any rise above 30 feet, much of it by a rise above 29 feet. These portions are chiefly occupied by lumber yards, stock yards, bucket factories, and similar establishments, containing a vast quantity of material of a perishable nature, liable to sufier great damage. All the country on the left bank of the river almost as far back as the bluffs (with the exception of a few high places) from Alton, Ill., to a point opposite Cape Girardeau is liable to be flooded at a 30-foot stage on the Saint Louis gauge.

WARSAW, ILL.

The danger point on gauge is 12 feet; then it endangers the lowlands, which begin about 1¼ miles south of gauge, We have here some very sudden rises, as we are just below the mouth of the Des Moines river, which enters the river about one-half mile north of this place, and I find that the channel of the Mississippi is being thrown more to the east side of the dikes which have been put up by the Government on the west bank.

Highest and lowest waters at the river stations of the United States Signal Service.

Year.	Augusta, Ga.						Boonville, Mo.						Brownsville, Pa.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...	.....	...	....	.....	...	...	.....	...	...	.....	...	...	.....	...	...	.....	...	...
1872...	.....	...	....	.....	...	...	.....	...	...	.....	...	...	.....	...	...	.....	...	...
1873...	.....	...	....	.....	...	...	.....	...	...	.....	...	...	Nov. 25	26	6	Oct. 4	2	9
1874...	.....	...	....	.....	...	...	.....	...	...	Dec. 31	1	0	Apr. 10	28	0	June 25	3	3
1875...	Dec. 20	27	5	Sept. 12	4	5	July 7	18	10	Jan. 1	1	0	Aug. 3	35	10	Jan. 23	3	0
1876...	Apr. 12	25	7	Aug. 1	2	6	May 8	17	0	Feb. 7	1	4	Sept. 18	27	0	June 25	2	10
1877...	Apr. 14	29	9	Aug. 18	4	3	June 13	19	0	Jan. 1	3	5	Jan. 16	38	6	Jan. 6	2	4
1878...	Jan. 11	21	6	July —	3	10	July 6	16	3	Jan. 11	1	3	Dec. 11	23	4	Sept. 28	1	4
1879...	Dec. 16	30	1	July —	3	10	July 1	17	0	Feb. 17	1	10	Jan. 19	27	1	Oct. 25	1	5
1880...	Mar. 17	28	5	Oct. 27	4	2	July 13	14	3	Dec. 11	1	9	Dec. 6	30	0	May 23	3	9
1881...	Mar. 18	32	4	Sept. 15	4	0	May 3	21	11	Jan. 1	4	1	.....	...	...	.....	...	...
1882...	Feb. 10	27	0	July 18	4	11	June 30	16	7	Jan. 23	1	10	Mar. 21	21	0	.....	...	...
1883...	Jan. 22	30	10	Sept. 16	3	10	.....	...	...	.....	...	...	.....	...	...	.....	...	...

Highest and lowest waters at the river stations, &c.—Continued.

Year.	Brunswick, Mo.						Cairo, Ill.						Chattanooga, Tenn.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...																		
1872...																		
1873...							Mar. 26	42	7	Oct. 16, 17.	3	8						
1874...							Apr. 26, 27.	47	4	Nov. 10	3	0	May 1	29	8	Nov. 7	0	8
1875...	July 7	15	6	Jan. 4	—4	5	Aug. 7	45	2	Jan. 25	5	4	Mar. 1	53	11½	Oct. 29	2	6
1876...	May 9	14	5	Feb. 6	—5	0	Apr. 6	48	5	Dec. 30	0	3	Jan. 1	33	0	Oct. 19	1	0
1877...	June 12	15	5	Dec. 3, 4	—1	4	Apr. 14	40	7	Jan. 1	1	1	Apr. 11	28	10	Oct. 5	1	2
1878...	July 2, 3	11	11	Dec. 20	—4	0	Apr. 9	37	1	Oct. 18	6	0	Feb. 25	19	2	Sept. 15	0	11
1879...	July 1	12	3	Dec. 9	—2	6	Dec. 31	36	6	Oct. 9	2	7	Jan. 15	38	0	Oct. 9, 10	0	2
1880...	July 22, 24.	7	6	Nov. 20, 22.	—4	4	Mar. 21, 23.	44	7	Nov. 29	5	8	Mar. 19	38	4	Oct. 30	1	0
1881...	May 2	15	6				Apr. 19	45	10	Sept. 7	5	4	Feb. 14	22	5	Sept. 14	0	0
1882...	June 30	22	6	Feb. 3	0	0	Feb. 25	51	10½	Dec. 18	7	4	Jan. 20	40	3	Oct. 18	1	8
1883...							Feb. 26	52	2	Sept. 30	4	8	Jan. 23	38	2	Sept. 19	0	0

Year.	Cincinnati, Ohio.						Confluence, Pa.						Davenport, Iowa.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...	May 13	40	6	Oct. 12	2	8												
1872...	Apr. 13	41	9	Oct. 14	3	0												
1873...	Dec. 18	44	5	Oct. 12	3	8												
1874...	Jan. 11	47	11	Sept. 23	2	3	Dec. 29	12	8	Nov. 7	—0	7						
1875...	Aug. 6	55	5	Sept. 18	4	1	Aug. 2	13	6	Sept. 8, 9	—0	5	Apr. 29	12	11	Nov. 27,	0	2
1876...	Jan. 29	51	9	Sept. 4	6	3	Sept. 18	11	7	Sept. 2, 6	—0	7	Apr. 16	13	9	Jan. 12	1	6
1877...	Jan. 20	53	8	Oct. 7, 9	3	5	Nov. 24	11	7	Oct. 3	—0	6	Apr. 4, 5	9	11	Sept. 15,	0	6
1878...	Dec. 15	41	2	Oct. 22, 24.	4	4	Nov. 25	8	2	Oct. 12, 18.	—0	7	July 17	7	2	Sept. 19, 20.	0	11
1879...	Dec. 27	42	4	Oct. 23	2	5	Jan. 28	10	0	Oct. 12, 16.	—0	8	June 1	7	10	Sept. 30, Oct. 1, Dec. 14.	1	1
1880...	Feb. 17	53	3	Oct. 28, 29.	3	9	June 15	9	7	Oct. 16, 23.	—0	7	June 26	18	5	Nov. 20	1	7
1881...	Feb. 16	50	9	Sept. 17	1	11	Feb. 12	11	7	Sept. 11	—0	10	Apr. 12	16	6	July 22, 23.	5	4
1882...	Feb. 21	58	7	Nov. 1	6	0	Feb. 21	10	6				Apr. 23	14	1	Jan. 8	1	8
1883...	Feb. 15	66	4	Sept. 20	3	7							May 1	13	2	Nov. 19	1	11

Highest and lowest waters at the river stations, &c.—Continued.

Year.	Decatur, Ala.						Dubuque, Iowa.						Eugene City, Oreg.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...	.....	.....	.....	.....	.....	.....	May 12	16	10	Oct. 8	2	3	.....	.....	.....	.....	.....	.....
1872...	.....	.....	.....	.....	.....	.....	May 26	12	5	Nov. 23	2	7	.....	.....	.....	.....	.....	.....
1873...	.....	.....	.....	.....	.....	.....	June 14	15	8	Nov. 23	2	3	.....	.....	.....	.....	.....	.....
1874...	.....	.....	.....	.....	.....	.....	May 14	11	4	Dec. 1	1	9	.....	.....	.....	.....	.....	.....
1875...	Dec. 1	18	6	Oct. 31	1	0	Apr. 27	16	6	Nov. 30	1	0	.....	.....	.....	.....	.....	.....
1876...	Jan. 3	19	8	Oct. 22	0	1	May 29	16	8	Dec. 2	2	4	.....	.....	.....	.....	.....	.....
1877...	Apr. 13	18	4	Sept. 5	0	4	Jan. 18	8	8	Mar. 10	1	6	.....	.....	.....	.....	.....	.....
1878...	Feb. 26	13	4	Oct. 1	0	0	July 15	8	11	Dec. 11	1	7	.....	.....	.....	.....	.....	.....
1879...	Jan. 19	20	6	Oct. 3	0	1	May 29	10	7	Oct. 1	2	2	.....	.....	.....	.....	.....	.....
1880...	Dec. 5	23	9	Oct. 23	0	6	June 23, 24.	22	8	Mar. 18	2	5	.....	.....	.....	Nov. 28	0	6
1881...	Mar. 20	16	10	Sept. 14	—0	8	Oct. 24	21	2	Sept. 1	5	1	Jan. —	22	0	.....	.....	.....
1882...	Jan. 23	23	9	.....	.....	.....	Apr. 20	16	9	Jan. 5	3	3	.....	.....	.....	.....	.....	.....
1883...	.....	.....	.....	.....	.....	.....	Apr. 27	16	8	Nov. 20	2	8	.....	.....	.....	.....	.....	.....

Year.	Evansville, Ind.						Fort Smith, Ark.						Freeport, Pa.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1872...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1873...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Dec. 13	29	3	June 23	—0	3
1874...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Jan. 8	23	4	Nov. 7	—0	9
1875...	Aug. 11	41	11	Sept. 22	2	6	.....	.....	.....	.....	.....	.....	Apr. 3	21	0	Sept. 9	0	2
1876...	Jan. 31	43	4	Dec. 20	3	10	.....	.....	.....	.....	.....	.....	Feb. 12	19	0	Sept. 1	0	0
1877...	Jan. 23	41	6	Oct. 14	0	1	.....	.....	.....	.....	.....	.....	Mar. 10	19	1	Sept. 25	0	0
1878...	Dec. 18	31	10	Oct. 28	1	5	.....	.....	.....	.....	.....	.....	Dec. 11	23	0	Aug. 30	0	2
1879...	Dec. 30	37	4	Nov. 14	0	8	Apr. 24	5	3	Sept. 30	—5	1	Mar. 12	22	10	Oct. 16	—0	6
1880...	Feb. 21	42	1	Oct. 8	2	1	Apr. 5	5	11	Dec. 31	—5	2	Jan. 1	17	6	Sept. 27	0	2
1881...	Feb. 19	38	11	Sept. 18	0	3	Feb. 9	7	5	Jan. 2	—5	5	June 10	29	5	Sept. 19	—0	7
1882...	Feb. 25	44	11	.....	.....	.....	Feb. 23	14	9	.....	.....	.....	Jan. 28	33	0	.....	.....	.....

Year.	Helena, Ark.						*Hermann, Mo.						Jefferson City, Mo.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1872...	Apr. 26	39	0	Dec. 26	0	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1873...	Apr. 20	39	8	Oct. 19	4	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1874...	May 11	45	10	Nov. 16	3	8	June 19	12	5	Dec. 29	0	0	.....	.....	.....	.....	.....	.....
1875...	Apr. 12	42	5	Nov. 9	7	7	Aug. 1	17	10	Jan. 5	—1	8	July 31	18	0	Jan. 11 to 23.	0	4
1876...	Apr. 18	44	10	Dec. 31	3	5	July 6	18	9	Dec. 9	—0	11	July 5,6	15	8	Dec. 18 to 23.	1	2
1877...	Apr. 30	41	10	Jan. 4	1	8	June 13	18	4	Oct. 13	2	3	June 13, 14.	17	3	Jan. 25 to 27.	1	8
1878...	May 3	38	10	Oct. 2	7	2	July 8	14	5	Dec. 21	—5	0	June 30	17	11	Dec. 16 to 17.	0	0
1879...	Jan. 31	37	2	Nov. 14	5	1	June 29	15	4	Dec. 22	—0	10	June 28	15	0	Dec. 22	0	4
1880...	May 4	45	4	Nov. 3	8	1	July 15	12	7	Dec. 6	—0	10	July 14	14	0	Dec. 31	0	3
1881...	May 14	43	8	Sept. 13	6	4	May 19	19	7	.....	.....	.....	May 4	18	9	Jan. 1	0	5
1882...	Mar. 9	47	2.5	.....	.....	.....	June 30	20	4	.....	.....	.....	.....	.....	.....	.....	.....	.....

*These observations are from the old gauge, whose zero was 5 feet above the present zero.

Highest and lowest waters at the river stations, &c.—Continued.

Year.	Kansas City, Mo.						Keokuk, Iowa.						La Crosse, Wis.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871																		
1872																		
1873																		
1874				Dec. 2	1	6	Mar. 26, 27.	9	6	Dec. 31	1	4	May 10	8	5	Nov. 28	2	8
1875	Apr. 30	17	10	Nov. 30	1	10	July 9	13	8	Dec. 19	0	9	Apr. 22	9	7	Aug. 24	—1	5
1876	June 16	18	0	Dec. 9	2	0	Apr. 17	17	3	Feb. 4	1	4	May 22	9	4	July 25	—0	2
1877	June 10	22	3	Dec. 17	3	10	Apr. 9, 10.	12	4	Oct. 1	0	9	July 12, 13.	4	11	Aug. 26	—2	3
1878	July 2	19	10	Jan. 12, 13.	3	6	June 10	11	9	Jan. 12	1	6	Apr. 30	4	5	Sept. 16 to 19.	—0	8
1879	June 30	19	3	Mar. 1	3	2	June 2	9	2	Dec. 20	0	0	July 19, 20.	7	10	Sept. 17 to 29.	0	6
1880	July 10 to 12.	16	8	Nov. 22	2	0	June 29	18	2	Nov. 23, 24.	0	3	June 19	15	2	Mar. 24 to 26.	1	0
1881	Apr. 30	26	4½	Feb. 23	4	6	Apr. 24, 25.	18	2	Sept. 1	3	6	May 4, 5.	12	0	Apr. 12, 13.	2	8
1882	June 30	18	10	Jan. 5	2	4	Apr. 25	16	8	Jan. 19	2	4	Apr. 16	10	8	Oct. 7	1	10
1883							Feb. 19	16	4	Dec. 21	0	0	Apr. 22	10	11	Sept. 20	1	0

Year.	Leavenworth, Kans.						Le Claire, Iowa.						Little Rock, Ark.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871																		
1872																		
1873																		
1874				Dec. 24	2	3												
1875	Apr. 30	17	3	Jan. 1	2	3	Apr. 30	10	4	Dec. 2	—0	3						
1876	July 6	16	5	Dec. 2, 3, & 10	3	3	June 1	10	3	Dec. 4	—0	3						
1877	June 13	19	8	Dec. 19	3	10	Apr. 3	6	11	Mar. 12	—0	1						
1878	July 2	18	6	Jan. 10	3	7	June 5	5	6	Dec. 14	—0	6						
1879	June 30	16	5	Mar. 1	3	3	June 1	6	6	Dec. 14	+1	0				Oct. 12	—0	9
1880	July 15	16	0	Feb. 3, 4, & 8.	2	9	June 25	14	6	Oct. 14	1	10	Mar. 14	14	8	Nov. 6, 7.	—0	6
1881	Apr. 29,	25	10	Nov. 11	1	6	Oct. 26	13	11				Feb. 20	17	1	Sept. 16	—2	0
1882	June 30	17	10	Dec. 14	1	4							Feb. 24	21	8	Sept. 20	—1	1
1883	June 26	21	5	July 26	2	3							Feb. 19	20	10	July 15	2	6

Highest and lowest waters at the river stations, &c.—Continued.

Year.	Louisville, Ky.						Marysville, Cal.						Memphis, Tenn.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...																Dec. 29	—0	11
1872...													Apr. 24	31	6	Dec. 25	—0	11
1873...	Dec. 19	18	6	Oct. 9, 12–17.	2	4							Mar. 3	32	6	Oct. 30	1	0
1874..	Jan. 12, 13.	25	0	Sept. 24	2	1							May 2	34	0	Nov. 16	1	5
1875...	Aug. 7	29	7	Sept. 22, 23.	3	0							Aug. 15	33	1	Jan. 27	3	2
1876...	Jan. 29	31	0	Dec. 18	4	1							Apr. 8	34	1	Dec. 30	1	2
1877...	Jan. 21	30	0	Oct. 8	2	6							Apr. 29	32	1	Jan. 2	0	8
1878...	Dec. 17	16	0	Oct. 25, 27.	3	0							May 2	29	1	Oct. 24	2	11
1879...	Dec. 28	20	6	Oct. 9	1	11							Jan. 29	28	1	Oct. 9	1	0
1880...	Feb. 18, 19.	30	6	Oct. 2, 3, and 29.	3	0							Mar. 24	33	5	Oct. 31	2	7
1881..	Feb. 17	22	8	Sept. 22	1	11	Sept. 4	18	2				Apr. 26	34	2	Sept. 10	3	0
1882...	Feb. 22	37	5	Oct. 23	4	6							Mar. 6	36	0	Dec. 22	3	7
1883...	Feb. 16	44	5	Sept. 24	3	1							Mar. 5	35	8	Oct. 1	2	3

Year.	Morgantown, W. Va.						Nashville, Tenn.						New Geneva, Pa.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...																		
1872...							Apr. 15	39	5	Sept. 23, 24; Oct. 29.	0	2						
1873...							Feb. 21, 22.	39	0	Oct. 12, 16, 17.	0	6						
1874...							Apr. 16, 17.	49	2	July 8–10.	1	0	Dec. 29	21	9	Nov. 10	0	7
1875...	Aug. 3	25	0	Jan. 1–3	0	7	Mar. 2	41	4	Sept. 13	1	6	Aug. 3	31	4	Sept. 15	1	0
1876...	Jan. 24	13	4	Jan. 2–5; Aug. 6, 7; Oct. 29.	0	4	Jan. 29	34	6	Oct. 19–21.	0	10	Sept. 18	20	11	Jan. 17, 18.	1	4
1877	Jan. 16	27	6	Aug. 29–31; Sept. 4–17.	0	4	Jan. 22	40	4	Sept. 4; Oct. 20, 21.	1	1	Jan. 16	36	4	Oct. 2, 3	0	10
1878...	Nov. 23, 28.	13	8	Oct. 16	0	3	Apr. 26	27	3	Sept. 29; Oct. 9.	0	4	Dec. 11	21	2	Oct. 17–21.	1	0
1879...	Dec. 25	15	3	July 2–4	0	2	Jan. 19	41	4	Oct. 3	0	5	Jan. 18	18	10	Nov. 1–9	0	9
1880...	Dec. 5	22	6	Dec. 27	2	9	Mar. 17	46	6	Sept. 26	0	7	Feb. 14	26	3	Aug. 2	1	7
1881...				Aug. 31	0	1	Jan. 24	33	0	Sept. 12	0	3	Apr. 14	18	8	Oct. 1	0	5
1882...	Mar. 21	20	0				Jan. 22	54	7	Oct. 25	1	6						
1883...							Feb. 13,	41	5	Sept. 18	0	5						

Highest and lowest waters at the river stations, &c.—Continued.

Year.	New Orleans, La.						Oil City, Pa.						Omaha, Nebr.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...																		
1872...																		
1873...	May 21	—2	8	Nov. 8	—14	5												
1874...	*Apr. 16	+0	6	Nov. 28	—15	9	Dec. 29	8	0	Nov. 1–16.	—0	4				Dec. 4	2	2
1875...	Apr. 22	—4	0	Nov. 16	—14	10	Apr. 2	11	5	Sept. 9	—0	5	Apr. 27	17	10	Nov. 23	1	10
1876...	May 10	—2	10	Dec. 30	—16	2	Feb. 12	11	1	Aug. 19–25.	—0	4	June 20	14	10	Dec. 2	1	7
1877...	May 30	—3	7	Jan. 3	—15	10	Mar. 10	12	4	Sept. 30	—0	5	June 13	17	5	Dec. 18	5	2
1878...	May 19	—3	6	Dec. 28	—14	3	Dec. 10	11	9	Oct. 16	—0	3	June 25	17	10	Dec. 14	4	9
1879...	Feb. 16	—3	8	Nov. 22	—14	7	Mar. 11	13	6	Oct. 17	—0	6	June 28	17	0	Dec. 10	2	1
1880...	Apr. 24	—0	11	Nov. 2	—14	10	Jan. 7	6	6	Sept. 19	—0	6	July 9	17	1	Nov. 27	4	5
1881...	Apr. 18	—2	2	Sept. 10	—14	2	Feb. 10	14	6	Sept. 22	—0	8	Apr. 25	23	10	Nov. 30	3	11
1882...	Mar. 27	—0	5	Oct. 28	—13	6							June 28	14	6	Dec. 3	3	0
1883...	Apr. 7	0	0	Oct. 8	—13	8							May 25	14	2	Dec. 20	2	10

* Zero was changed on April 16, 1874, so that all heights before this date refer to a zero 6 inches lower than those afterwards.

Year.	Oroville, Cal.						Paducah, Ky.						Pittsburg, Pa.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871–2																		
1873–4																		
1875...							Mar. 23	44	4	Oct. 24	3	3	Aug. 3	21	0	Sept. 10	0	4
1876...							Feb. 5	44	11	Dec. 3	0	3	Sept. 19	20	9	Sept. 3	0	2
1877...							Jan. 27	38	10	Sept. 16	1	3	Jan. 17	22	1	Oct. 2	—0	7
1878...							Apr. 29	29	0	Oct. 31	0	11	Dec. 11	24	6	Oct. 20	—0	7
1879...							Jan. 25	38	10	Oct. 16	0	8	Mar. 12	19	11	Oct. 19	—1	1
1880...	Feb. 3	19	0	Dec. 3	—0	3	Mar. 23	44	0	Oct. 30	2	2	Feb. 14	21	7	Oct. 20	—0	6
1881...							Feb. 24	40	6	Sept. 17	0	0	Jan. 10	27	1	Sept. 28	—1	3
1882...													Jan. 28	21	8	Oct. 26	0	6
1883...													Feb. 8	27	6	Sept. 16	0	1

Highest and lowest waters at the river stations, &c.—Continued.

Year.	Plattsmouth, Febr.						Portland, Oreg.						Sacramento, Cal.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...																		
1872...																		
1873...	July 3	16	5	Dec. 2	0	0												
1874...	June 16	7	8	Dec. 19	—0	9							May 26, 27.	22	7	Oct. 2 to 20	4	7
1875...	Apr. 28	13	3	Nov. 22	—0	7							Jan. 26	22	2	Oct. 7 to 29	4	4
1876...	June 21	12	0	Dec. 2	0	3	June 24	28	2	Dec. 23	1	2	Mar. 8	24	8	Oct. 11 to 16.	7	1
1877...	July 13	13	11	Mar. 9	—0	8	Mar. 16 to 19.	19	1	Jan. 25	1	2	Mar. 16 to 19.	18	2	Aug. 31 to Oct. 21.	5	2
1878...	June 25	14	1	Dec. 23	0	0	June 15	14	8	Dec. 30	0	1	Feb. 25	26	0	Sept. 18	5	3
1879...	June 28	12	5	Dec. 12	0	4	July 1, 2.	19	4	Jan. 3	—0	1		17	6	Sept. 22	5	10
1880...	July 8	13	1	Mar. 15	—1	3	July 1, 2.	27	4	Nov. 30	0	11	Apr. 22	24	6	Nov. 8 to 23.	7	5
1881...	Apr. 25	19	3										Feb. 4	26	6			

Year.	Saint Louis, Mo.						Saint Paul, Minn.						Umatilla, Oreg.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...																		
1872...	June 12 to 14.	23	0	Dec. 4	2	6	May 20, 21.	7	9	Oct. 26, 27.	1	11						
1873...	Apr. 11	25	3	Dec. 1	4	6	Apr. 21	16	5	Sept. 22	2	5						
1874...	June 20	18	5	Dec. 30, 31.	3	4	July 2	11	7	Nov. 25 to 28.	3	0						
1875...	Aug. 3	29	11	Jan. 3	2	9	Apr. 16	18	0	Aug. 22	2	1						
1876...	May 10	32	3	Feb. 7	5	0	Apr. 10	11	0	Nov. 26	1	11						
1877...	June 14	26	7	Oct. 4	6	10	May 25, 26.	7	8	Sept. 5 to 13.	1	9						
1878...	June 15	25	9	Dec. 27	5	11	Apr. 27	6	8	Dec. 3	0	7	June 12	18	0	Dec. 31	0	11
1879...	July 3	21	2	Dec. 26	3	6	July 11	10	9	Sept. 28	0	11	June 17	22	2	Jan. 5	1	0
1880...	July 10 to 12.	25	5	Nov. 29	2	10	June 17	15	3	Oct. 10, 14.	1	8	July 2	28	1	Mar. 20	1	5
1881...	Nov. 19	29	6	Sept. 3	8	7	Apr. 29	19	8	Aug. 14	3	4	June 11, 17.	20	10			
1882...	Feb. 22	28	3	Dec. 18	2	10	Apr. 13	13	4	Nov. 29	2	7						
1883...	June 25	34	10	June 12	4	5	Apr. 22	12	6	Sept. 16	1	6						

Highest and lowest waters at the river stations, &c.—Continued.

Year.	Vicksburg, Miss.						Warsaw, Ill.						Yankton, Dak.					
	Highest.			Lowest.			Highest.			Lowest.			Highest.			Lowest.		
	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.	Date.	Feet.	Inches.
1871...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1872...	.....	.....	.....	Jan. 1	0	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1873...	May 28	40	7	Jan. —	2	4	.....	.....	.....	.....	.....	.....	Nov. 29	15	2	June 30, July 1.	4	2
1874...	Apr. 29	45	8	Nov. 16	3	0	Mar. 12	10	0	Dec. 13	2	0	July 4	15	0	Nov. 21, 22.	5	9
1875...	May 15	40	11	Jan. 31	8	7	Apr. 11	14	9	Dec. 19	1	3	Apr. 24,	15	10	Nov. 7	5	8
1876...	May 10	44	11	Dec. 31	4	0	Mar. 22	16	11	Nov. 8	2	0	Apr. 13	13	9	Dec. 11–13.	3	9
1877...	May 13	41	7	Jan. 7	2	3	June 26	13	4	Jan. 1	1	0	June 11, 12.	13	0	Dec. 29–31.	4	0
1878...	Mar. 27	40	11	(*)	.....	.....	June 8	11	2	Feb. —	1	0	June 22, 23.	11	6	Dec. 13	2	9
1879...	Apr. 15	35	4	(*)	.....	.....	June 2	9	10	Oct. 2	1	11	June 26, 27.	12	6	Nov. 5, 6, 7.	2	7
1880...	Apr. 9	43	2	Oct. 25	7	8	June 28	19	8	Nov. 23	2	0	July 5	13	2	Mar. 16	0	10
1881...	May 11	41	7	Sept. 14	3	8	Oct. 28	20	8	Aug. 28	3	8	Apr. 5	29	3	Oct. 20	1	9
1.82...	Mar. 20	48	9	Dec. 26	7	7	.....	.....	.....	.....	.....	.....	June 27	18	4	Nov. 2	1	9
1883...	Apr. 6	43	10	Oct. 5	2	11	.....	.....	.....	.....	.....	.....	Mar. 25	10	4	Nov. 29	0	9

* No reading. By improvements the river left the gauge dry, and a new one had to be erected at Kleinston. The zero is the same as the old gauge.

THE FLOODS OF 1882.

WAR DEPARTMENT,
OFFICE OF THE CHIEF SIGNAL OFFICER,
Washington City, May 18, 1882.

SIR: I have the honor to inclose herewith blank forms for report on the recent overflow of the river in your vicinity. The blanks explain themselves.

It is the purpose of this Bureau to publish a comprehensive report upon the flood as soon as the necessary data can be obtained from reliable sources. Your co-operation in this important work is earnestly solicited, as its success depends upon the interest taken in the matter by persons who reside in the overflowed districts and were present during the time of the flood.

Will you kindly fill up one of the blanks with the information called for therein and forward it to this office at your earliest convenience? A copy of the report will be sent you as soon as published.

I am, very respectfully, your obedient servant,

W. B. HAZEN,
Brig. and Bvt. Maj. Gen'l, Chief Signal Officer, U. S. A.

CIRCULAR, FLOOD OF 1882.

What extent of the levee in your vicinity was broken?

State height in feet above danger line reached during the flood; also date danger line was reached.

What fluctuations were noticed during flood?

Give date of highest water in your vicinity during recent flood.

What point of reference is used to measure changes in the river at your place?

How many feet did the river rise when highest above this point of reference?

Give highest water previous to recent flood, with date of same.

How far inland from river did flood reach in your vicinity;

What was width of overflowed district, measured east and west?

Describe any peculiarities you may have observed in connection with the recent rise of the river and its decline.

What was rate of current (if any) in your immediate vicinity?

Give estimated damage to lands and buildings in your county.

Give estimated damage to provisions and supplies in your county.

Give estimated damage to stock and farming implements in your county.

Give estimated damage to staple products, grain, cotton, sugar, &c., in your county.

Here give grand total damage done in your county.

Give names of persons known to have lost their lives.

ACKNOWLEDGMENT.

WAR DEPARTMENT,
OFFICE OF THE CHIEF SIGNAL OFFICER,
Washington City, ——— —, 188–.

SIR: I have the honor to acknowledge with thanks the receipt of your report of the recent flood in the lower Mississippi valley. Similar reports have been received from other parts of the overflowed region, and a general report is in preparation, and when published a copy will be furnished you.

I am, very respectfully, your obedient servant,

W. B. HAZEN,
Brig. and Bvt. Maj. Gen'l, Chief Signal Officer, U. S. A.

ABSTRACT OF A REPORT ON THE FLOODS OF 1882.

Early in May of 1882 the circular, above given, having seventeen questions relating to the spring floods, with the accompanying letter of transmittal, was widely distributed throughout the flooded districts, through the nearest offices of the Signal Service. Answers to these circulars were received from 372 persons, and the accompanying acknowledgment has been sent. Besides these replies, there have been used in making up this report rainfall statistics from 22 regular stations of the Signal Service and 57 volunteer reports, also records from 15 river stations; all these stations are either upon the Missouri, Mississippi, and Ohio rivers or upon their watersheds.

On projecting the river records so as to show the oscillations, the following Table 1 was prepared:

TABLE 1.—*Showing the dates on which the danger line was reached, together with the date and record of highest water during the first six months of* 1882.

Station.	Danger line.		Date of highest water.	Gauge reading at highest.	Above danger.
	Date of reaching.	Date of receding.			
				Feet.	*Feet.*
Cincinnati, Ohio	Feb. 18	Feb. 27	Feb. 21	58.5	8.5
Louisville, Ky	Feb. 17	Feb. 28	Feb. 22	37.2	12.2
Paducah, Ky	Jan. 15	Mar. 21	Feb. 26	49.8	9.8
Cairo, Ill	Jan. 14	Apr. 4	Feb. 25 and 26.	51.8	11.8
Memphis, Tenn	Jan. 25	Apr. 29	Mar. 7	36.0	2.0
Helena, Ark	Jan. 17	Apr. 18	Mar. 9	47.4	7.4
Vicksburg, Miss	Jan. 21	May 4	Mar. 20	48.7	7.7
New Orleans, La	Jan. 28	May 11	Mar. 27	— 0.4	2.6
Le Claire, Iowa	Apr. 20	Apr. 28	Apr. 22	11.3	1.3
Keokuk, Iowa	Apr. 22	May 2	Apr. 25	17.1	2.1
Warsaw, Ill	Apr. 9	May 7	Apr. 25	17.8	5.8
Nashville, Tenn	Jan 11, Mar. 9.	Feb. 2, Mar. 16.	Jan. 22	54.5	14.5

TABLE 2.—*Showing the dates previous to* 1882 *on which the danger line was reached, and the date and record of highest water.*

Station.	Danger line.		Date of highest water.	Gauge reading.	Amount above danger line.
	Date of reaching.	Date of receding.			
				Feet.	*Feet.*
Cairo, Ill	Feb. 19, 1873	Mar. 2	Feb. 25	42.4	2.4
	Apr. 8, 1873	Apr. 17	Apr. 14	42.2	2.2
Cairo, Ill	Feb. 25, 1874	Mar. 14	Mar. 10	45.2	5.2
	Apr. 15, 1874	May 13	Apr. 26	47.9	7.9
Nashville, Tenn	Apr. 10, 1874	Apr. 25	Apr. 16	49.7	9.7
Vicksburg, Miss	Mar. 13, 1874	May 4	May 1	47.1	6.1
Memphis, Tenn	Apr. 19, 1874	May 14	May 1	35.0	1.0
Vicksburg, Miss	Mar. 28, 1875	May 9	Apr. 24	43.0	2.0
Cairo, Ill	Mar. 8, 1875	Apr. 2	Mar. 20	44.0	4.0
Cincinnati, Ohio	Aug. 3, 1875	Aug. 9	Aug. 7	55.2	5.2
Louisville, Ky	Aug. 5, 1875	Aug. 10	Aug. 7	29.6	6.6
Cairo, Ill	July 20, 1875	Aug. 10	Aug. 8	45.3	5.3
Cairo, Ill	Jan. 29, 1876	Feb. 15	Feb. 4	45.3	5.3
	Mar. 22, 1876	Apr. 13	Apr. 6	46.6	6.6
Memphis, Tenn	Mar. 31, 1876	Apr. 17	Apr. 7	35.0	1.0
Vicksburg, Miss	Feb. 12, 1876	Mar. 16	Mar. 8	42.3	1.3
	Apr. 28, 1876	June 13	May 19	44.7	3.7
Nashville, Tenn	Feb. 13, 1880	Feb. 22	Feb. 19	44.0	4.0
	Mar. 13, 1880	Mar. 22	Mar. 17	46.5	6.5
Cairo, Ill	Feb. 19, 1880	Mar. 30	Mar. 20	44.8	4.8
Vicksburg, Miss	Mar. 10, 1880	May 3	Apr. 11	44.3	3.3
Cairo, Ill	Apr. 13, 1881	May 11	Apr. 19	44.2	4.2
Leavenworth, Kans	Apr. 23, 1881	May 3	Apr. 29	26.0	6.0

I have also prepared from the curves of river oscillations, published in the "Report of the Chief Signal Officer" for the years 1873 to 1881, inclusive, a second similar Table 2 for purposes of comparison.

These tables show strikingly the longer continuance and greater depths of water in the floods of 1882 over those of any other year since 1873. Table 1 also shows that there were two distinct flood seasons, the first one, in January, in the Cumberland river, and the second, in February and March, in the Ohio and lower Mississippi rivers. To these may be added a third partial flood season, in the upper Mississippi river, occurring the last of April and the first of May; this, however, was of very slight extent, and little or no damage accompanied it.

In looking for the causes of these floods I have prepared Table 3, showing monthly rainfalls during the first four months of 1882 at various stations, and the departures from the mean value for the past ten years. The enormous excess in January of 10 inches and more in the valley of the Cumberland, occurring almost wholly before the 22d of the month, readily accounts for the floods of the same.

TABLE 3.—*Rainfall (monthly) at various stations during* 1882.

Station.	January.	Departure from mean.	February.	Departure from mean.	March.	Departure from mean.	April.	Departure from mean.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Yankton	0.04	— .52	0.09	— .71	0.06	—1.15	2.93	+ .36
Omaha	.74	+ .24	.60	— .09	.79	— .71	4.31	+1.00
Leavenworth	.83	— .57	1.17	— .29	1.15	—1.29	4.15	+ .70
Saint Louis	2.80	+ .54	8.94	+6.07	3.49	+ .22	3.58	— .16
Saint Paul	.67	— .39	2.35	+1.07	3.25	+1.50	1.61	— .03
La Crosse	.75	— .45	1.11	— .04	2.37	+ .33	1.96	— .03
Dubuque	.84	— .63	.59	— .80	1.49	—1.03	4.47	+1.44
Davenport	.90	— .90	.62	— .75	2.90	+ .48	3.15	— .11
Keokuk	1.07	— .59	1.54	+ .20	3.30	+ .90	3.22	— .04
Pittsburg	4.58	+ 1.68	3.14	+ .86	5.18	+ .51	1.39	—1.15
Cincinnati	6.02	+ 2.22	7.04	+3.60	6.17	+2.09	2.71	— .63
Indianapolis	3.74	+ .66	7.28	+3.90	6.11	+1.81	3.68	.00
Louisville	6.29	+ 1.97	9.69	+5.71	5.85	+1.30	2.17	—2.31
Knoxville	16.98	+10.95	6.10	+1.17	4.35	—1.18	3.88	—1.84
Nashville	14.49	+ 9.17	8.58	+3.44	9.36	+4.05	3.55	—2.12
Cairo	6.35	+ 1.79	10.14	+6.03	4.22	— .16	4.14	— .16
Memphis	12.87	+ 6.46	9.92	+4.58	9.10	+2.92	3.56	—3.20
Vicksburg	13.83	+ 8.77	7.15	+2.08	7.41	+ .37	5.44	—1.65
New Orleans	4.54	— .41	4.04	— .82	.92	—5.01	4.83	—1.16

In order to study into the causes for the extraordinary high waters in the lower Mississippi, Tables 4 and 5 have been prepared. These show, first, the monthly rainfall at three typical stations in the Missouri and Mississippi watersheds, namely, Leavenworth, Keokuk, and Saint Louis, and a corresponding number for the Ohio valley, namely, Knoxville, Nashville, and Louisville; second, the mean monthly height of the Mississippi river at Saint Louis and Cairo and of the Ohio at Louisville.

TABLE 4.—*Giving the monthly rainfall at Leavenworth, Kans., Keokuk, Iowa, and Saint Louis, Mo., together with the mean monthly river-gauge reading at Saint Louis, Mo., and Cairo, Ill.*

Date.	Monthly rainfall.				Mean height of river at—	
	Leavenworth	Keokuk.	Saint Louis.	Mean.	Saint Louis.	Cairo.
1872.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*
January	0.12	0.07	0.64	0.28	4.6	.....
February	.87	.39	1.15	.80	5.9	.....
March	1.95	2.88	2.43	2.42	8.1	.....
April	2.98	3.66	3.17	3.27	15.3	.....
May	7.91	3.70	5.97	5.86	18.1	.....
June	4.75	5.81	4.28	4.95	20.7	.....
July	9.92	6.77	4.41	7.03	17.7	.....
August	6.56	1.97	.93	3.15	12.6	.....
Septemper	4.22	2.26	3.45	3.31	8.1	.....
October	2.06	.42	.55	1.01	5.7	.....
November	.06	.74	2.01	.94	5.7	.....
December	1.34	.50	1.70	1.18	4.3	.....
1873.						
January	3.02	3.31	3.53	3.29	9.0	.....
February	1.03	.53	1.52	1.03	9.6	.....
March	1.75	.51	2.10	1.45	12.8	.....
April	5.07	5.65	6.86	5.86	19.6	.....
May	5.38	3.42	5.27	4.69	26.5	.....
June	3.15	1.21	6.68	3.68	23.9	27.6
July	2.04	8.77	5.96	5.59	22.4	25.0
August	2.40	.54	.07	1.00	11.5	12.7
September	3.64	3.73	3.02	3.46	7.5	5.4
October	1.56	4.69	3.27	3.17	6.8	4.0
November	.89	1.43	1.64	1.32	6.0	10.5
December	5.24	8.56	5.10	6.30	9.5	27.0
1874.						
January	3.14	3.66	3.04	3.28	5.3	24.8
February	1.35	.89	3.66	1.97	10.6	30.9
March	3.05	1.14	4.36	2.85	15.3	40.4
April	2.80	2.40	3.43	2.88	16.4	41.4
May	1.60	1.65	3.70	2.32	15.3	31.6
June	4.96	4.01	2.06	3.67	15.5	14.7
July	3.23	4.54	5.71	4.49	13.3	11.6
August	1.72	3.87	4.70	3.43	8.1	8.3
September	5.50	7.92	2.32	5.25	7.7	7.0
October	1.49	1.96	1.09	1.51	8.1	5.9
November	3.46	2.17	2.32	2.65	6.9	5.5
December	1.35	1.26	1.46	1.36	4.8	9.9
1875.						
January	0.23	0.61	0.54	0.46	5.5	14.6
February	1.25	1.84	2.59	1.89	5.4	19.3
March	2.50	1.67	4.08	2.75	9.0	40.3
April	1.67	.89	2.53	1.70	18.0	33.5
May	3.53	6.70	5.48	5.24	19.6	28.4
June	3.85	8.33	10.84	7.67	20.2	22.0
July	8.82	12.70	4.49	10.34	25.5	36.2
August	3.73	3.83	2.66	3.41	17.4	35.2
September	1.97	4.62	.24	2.28	15.8	15.1
October	.72	2.71	1.23	1.55	10.3	9.5
November	.39	.59	.89	.62	7.7	11.5
December	2.60	3.93	2.42	2.98	5.5	14.4
1876.						
January	1.42	3.66	4.75	3.28	11.8	33.5
February	.20	1.45	2.86	1.51	9.9	41.1
March	5.17	3.45	6.90	5.17	15.5	32.1
April	7.65	3.99	2.25	4.63	25.9	41.9
May	6.78	5.28	3.13	5.06	24.5	35.2
June	5.71	6.70	6.43	6.28	23.7	28.5
July	4.01	6.79	5.18	5.33	25.1	30.4
August	3.40	4.03	5.03	4.15	13.7	16.2
September	3.56	11.08	7.63	7.42	18.3	19.3
October	2.79	2.12	1.66	2.19	11.1	10.9
November	2.87	2.82	1.74	2.48	11.4	11.3
December	.31	.23	.18	.24	10.8	4.7
1877.						
January	.71	.84	1.24	.94	10.4	19.1
February	.60	.15	.88	.51	11.3	2.02

TABLE 4.—*Giving the monthly rainfall, &c.*—Continued.

Date	Monthly rainfall.				Mean height of river at—	
	Leavenworth	Keokuk.	Saint Louis.	Mean.	Saint Louis.	Cairo.
1877.—Continued.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*
March	4.39	3.76	3.41	3.85	10.2	23.2
April	7.14	4.22	2.86	4.74	20.7	37.8
May	8.67	5.55	3.11	5.78	12.5	31.9
June	10.00	7.82	8.69	8.84	23.9	27.1
July	5.34	7.06	2.88	5.09	21.1	23.5
August	2.85	2.52	2.61	2.66	12.2	11.0
September	1.95	3.61	3.56	3.04	8.9	6.6
October	4.87	7.11	4.92	5.63	8.8	5.6
November	2.44	3.05	3.76	3.08	10.8	13.4
December	3.18	2.90	3.34	3.14	11.8	18.2
1878.						
January	2.34	.17	2.36	1.62	11.6	21.9
February	2.94	2.95	1.69	2.53	14.3	28.4
March	2.35	3.78	2.79	2.97	16.8	**30.8**
April	2.86	2.31	6.74	3.97	16.5	25.1
May	5.28	3.47	4.63	**4.46**	20.8	30.5
June	5.27	3.93	2.40	3.87	**23.7**	26.4
July	3.08	2.37	3.92	3.12	20.1	21.1
August	3.31	5.27	4.75	4.44	16.2	16.0
September	2.64	1.36	3.42	2.47	9.9	11.2
October	1.16	2.31	3.27	2.25	10.1	6.8
November	2.76	1.93	1.38	2.02	8.9	8.5
December	2.16	1.95	3.48	2.53	8.5	23.9
1879.						
January	1.16	.50	1.64	1.10	9.2	22.0
February	.54	.53	1.48	.85	8.5	26.5
March	.32	1.71	1.92	1.33	10.1	27.5
April	.42	1.56	2.31	1.43	13.9	32.7
May	3.04	2.27	.95	2.09	11.8	14.4
June	9.90	2.63	4.04	**5.52**	16.7	17.1
July	4.99	1.98	1.97	2.98	**17.9**	16.8
August	.18	4.57	2.23	2.33	13.0	13.5
September	3.41	1.12	1.34	1.96	8.6	11.4
October	4.25	.28	.68	1.74	8.0	4.1
November	7.85	3.91	4.30	5.35	10.3	8.2
December	2.34	1.45	2.84	2.21	9.3	25.1
1880.						
January	2.00	3.91	3.83	3.25	11.6	35.8
February	1.40	1.94	2.65	2.00	10.0	31.0
March	2.22	1.83	2.51	2.19	10.4	**41.9**
April	1.38	4.79	3.81	3.16	15.3	32.9
May	5.01	5.92	3.44	**4.79**	15.8	27.2
June	1.69	3.96	2.46	2.40	19.0	23.3
July	6.86	2.25	5.17	4.76	**22.6**	26.4
August	7.06	3 81	1.53	4.13	12.9	11.2
September	2.78	3.21	3.10	3.03	12.1	11.0
October	3.69	2.02	2.09	2.60	10.2	7.7
November	2.40	1.13	2.67	2.07	7.3	11.1
December	.40	.67	1 80	.96	5.5	19.5
1881.						
January	.44	.50	.49	.48	8.4	17.5
February	4.84	2.54	4.16	3.85	11.5	32.9
March	2.17	2.42	1.95	2.18	18.8	35.2
April	1.86	3.12	2.14	2.37	27.1	40.8
May	3.65	1.35	3.96	2.99	27.1	34.1
June	5.27	8.70	2.74	5.57	22.6	25.0
July	1.72	3.08	2.13	2.31	21.1	20.8
August	2.74	.81	.31	1.30	11.5	9.1
September	6.89	4.10	3.14	4.71	20.7	8.1
October	5.73	7.01	7.21	6.98	21.7	19.1
November	3.42	2.59	6.74	4.25	25.2	28.0
December	1.18	1.70	1.70	1.53	17.7	28.8
1882.						
January	.83	1.07	2.80	1.57	12.2	42.5
February	1.17	1.54	8.94	3.88	14.5	**47.5**
March	1.15	3.30	3.49	2.65	18.0	46.1
April	4.15	3.22	3.58	3.65	20.9	34.4
May	2.53	7.11	4.55	4.73	23.9	37.8
June	5.06	9.45	4.53	**6.35**	**26.7**	38.1

TABLE 5.—*Giving the monthly rainfall at Knoxville, Tenn., Nashville, Tenn., and Louisville, Ky., together with the mean monthly river-gauge reading at Louisville and Cairo.*

Date.	Monthly rainfall.				Mean height of river at—	
	Knoxville.	Nashville.	Louisville.	Mean	Louisville.	Cairo.
1874.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*
January	5.14	5.22	2.39	4.25	12.2	24.8
February	2.73	9.23	5.18	5.71	12.3	30.9
March	3.96	5.26	6.63	5.28	10.9	40.4
April	17.32	11.84	6.01	11.72	13.1	41.4
May	2.35	1.49	1.17	1.67	8.8	31.6
June	5.11	2.87	2.95	3.64	4.7	14.7
July	3.13	2.65	2.71	2.83	4.6	11.6
August	7.89	3.52	3.23	4.88	5.4	8.3
September	2.43	3.12	.62	2.09	3.1	7.0
October	.64	2.63	2.04	1.80	3.5	5.9
November	4.99	6.12	5.90	5.67	3.1	5.5
December	2.69	4.19	4.77	3.88	7.2	9.9
1875.						
January	6.92	6.15	2.42	5.16	7.6	14.6
February	10.18	3.06	2.09	5.11	8.1	19.3
March	13.07	8.14	4.54	8.58	13.3	40.3
April	5.86	4.25	.87	3.66	9.7	38.5
May	1.23	1.73	4.07	2.34	7.7	28.4
June	4.96	5.63	5.79	5.53	6.1	22.0
July	7.64	8.12	16.46	10.74	11.0	36.2
August	5.60	1.60	2.19	3.13	13.8	35.2
September	4.14	3.79	1.05	2.99	4.1	15.1
October	2.81	1.25	1.92	1.99	4.7	9.5
November	4.25	5.46	6.14	5.28	7.3	11.5
December	7.21	4.30	5.67	5.73	10.7	19.4
1876.						
January	3.99	6.41	11.63	7.34	15.1	33.5
February	4.90	2.22	2.96	3.46	14.5	41.1
March	5.89	5.28	6.01	5.73	10.5	32.1
April	2.78	3.62	4.50	3.63	10.3	41.9
May	6.25	3.40	1.00	3.55	8.2	35.2
June	4.07	5.65	6.52	5.41	6.0	28.5
July	3.93	7.15	3.61	3.90	6.7	30.4
August	1.87	5.77	4.29	3.98	6.2	16.2
September	1.60	2.52	2.66	2.26	7.6	19.3
October	1.81	2.68	7.61	4.03	6.2	10.9
November	2.36	1.26	1.63	1.75	6.5	11.3
December	1.74	.95	1.24	1.31	5.3	4.7
1877.						
January	7.49	4.05	3.95	5.16	15.3	19.1
February	1.15	1.06	.44	.88	8.2	20.2
March	6.65	4.95	4.93	5.51	10.0	23.2
April	8.79	9.47	5.31	7.86	9.7	37.8
May	1.64	1.25	3.98	2.29	8.4	31.9
June	4.50	6.02	5.57	5.36	6.8	27.1
July	2.12	3.25	4.19	3.19	6.3	23.5
August	2.01	4.16	2.70	2.96	3.8	11.0
September	7.38	5.40	3.02	5.27	3.4	6.6
October	3.70	2.61	1.81	2.71	3.4	5.6
November	6.57	4.93	4.49	5.33	6.1	13.4
December	2.36	2.49	4.19	3.01	7.8	18.2
1878.						
January	2.85	3.84	3.25	3.15	9.0	21.9
February	1.01	2.11	2.25	1.79	10.3	28.4
March	2.87	3.48	4.06	3.47	10.8	30.8
April	4.69	6.58	3.53	5.03	5.2	25.1
May	2.38	2.33	4.50	3.07	9.7	30.5
June	5.10	3.28	5.34	4.57	7.2	26.4
July	5.37	9.43	4.08	6.29	5.9	21.1
August	6.86	5.02	4.21	5.38	6.0	16.0
September	.73	1.28	2.52	1.51	6.8	11.2
October	5.40	2.17	3.44	3.67	3.9	6.8
November	5.40	3.20	4.78	4.46	6.9	8.5
December	5.10	6.04	5.10	5.41	12.5	23.9
1879.						
January	9.59	6.32	2.52	6.14	12.7	22.0
February	5.89	3.13	2.31	3.78	10.8	28.5

TABLE 5.—*Giving the monthly rainfall, &c.*– Continued.

Date.	Monthly rainfall.				Mean height of river at—	
	Knoxville.	Nashville.	Louisville.	Mean.	Louisville.	Cairo.
1879.—Continued.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*
March	3.17	3.81	5.66	4.21	12.0	27.5
April	3.96	2.88	4.63	3.82	9.8	**32.7**
May	3.43	2.88	1.68	2.66	6.2	14.4
June	1.99	2.50	3.39	2.96	5.1	17.1
July	3.28	8.47	1.18	4.31	3.8	16.8
August	2.89	4.62	10.02	5.84	5.9	13.5
September	.22	5.18	5.88	3.75	4.8	11.4
October	3.14	2.90	.59	2.21	2.3	4.1
November	3.11	5.85	4.90	4.62	3.8	8.2
December	8.28	9.15	7.93	8.45	9.3	25.1
1880.						
January	2.16	3.74	4.61	3.50	12.3	35.8
February	4.43	12.37	5.40	7.40	13.7	31.0
March	8.59	8.16	5.14	7.30	13.9	**41.9**
April	6.20	5.26	7.32	6.26	7.4	32.9
May	2.50	4.13	6.09	4.24	8.0	27.2
June	3.38	3.95	4.11	3.81	7.5	23.3
July	6.28	5.69	2.18	4.72	6.0	26.4
August	4.45	2.22	2.82	3.20	5.2	11.2
September	3.64	5.39	2.44	3.82	4.9	11.0
October	.71	7.24	6.39	4.78	3.7	7.7
November	5.36	5.77	3.83	4.99	9.2	11.1
December	3.74	3.32	3.52	3.53	9.0	19.5
1881.						
January	4.41	3.04	3.24	3.73	11.0	17.5
February	4.20	5.45	4.05	4.58	16.5	32.9
March	3.90	2.79	2.46	3.05	10.3	35.2
April	2.99	5.12	3.45	3.89	11.8	**40.8**
May	1.14	3.67	2.35	2.39	7.6	34.1
June	5.13	3.79	3.78	4.20	7.4	25.0
July	4.05	.86	2.18	2.36	5.1	20.9
August	1.77	1.81	.15	1.24	3.7	9.1
September	2.31	6.49	2.70	3.83	2.7	8.1
October	5.14	4.74	3.44	4.44	3.8	18.0
November	5.31	4.84	2.79	4.31	7.4	21.0
December	5.32	4.83	6.00	5.38	10.6	13.0
1882.						
January	16.98	14.49	6.29	**12.59**	19.1	42.5
February	6.10	8.58	9.69	8.12	**22.6**	**47.5**
March	4.35	9.36	5.85	6.52	14.3	46.1
April	3.88	3.55	2.17	3.20	8.7	34.4
May	6.77	7.34	7.46	7.19	12.3	37.8
June	3.56	2.51	5.23	3.79	11.2	38.1

The following may be noted as the characteristic of Table 4: first, the maximum mean rainfall over the Mississippi river watersheds occurring in June compares closely with the maximum height of the river at Saint Louis; second, in February, 1882, the Mississippi river is very much higher than usual.

Table 5 shows that in the Ohio watershed the maximum mean rainfall occurs in March, and the fluctuation of the river at Louisville closely follows that of the rainfall. We may safely say, then, that an unusually early spring, causing a more rapid melting of the snow, combined with excessive rainfalls, caused simultaneous high waters in both the Mississippi and Ohio rivers.

In pursuing this investigation I have prepared Table 6, showing, for the years from June, 1879, to June, 1882, the progress down the river of unusually high and low waters. This has developed the remarkable fact that while wave crests may be traced from Cincinnati, Ohio, on the upper Ohio river, to Vicksburg, Miss., the same is not true of wave crests appearing at Saint Louis, on the Mississippi river. The same fact is also shown in Tables 4 and 5, the maximum mean monthly heights appearing from one to two months *earlier* at Cairo than at Saint Louis, on the Mississippi river, but at *same* month nearly every year, when compared with those at Louisville, Ky., on the Ohio river.

TABLE 6.—*Showing dates on which highest and lowest waters reached various river stations, from June, 1879, to June, 1882.*

HIGHEST WATER.

Year.	Cincinnati.			Evansville.			Paducah.			Cairo.			Memphis.			Helena.			Vicksburg.			New Orleans.		
	Date.	Gauge reading.	Days from Cincinnati.	Date.	Gauge reading.	Days from Cincinnati.	Date.	Gauge reading.	Days from Cincinnati.	Date.	Gauge reading.	Days from Cincinnati.	Date.	Gauge reading.	Days from Cincinnati.	Date.	Gauge reading.	Days from Cincinnati.	Date.	Gauge reading.	Days from Cincinnati.	Date.	Gauge reading.	Days from Cincinnati.
		Feet.			*Feet.*			*Feet.*			*Feet.*			*Feet.*			*Feet.*			*Feet.*			*Feet.*	
1879	Sept. 3	25.5	0	Sept. 5	20.0	2	Sept. 7	16.2	4	Sept. 7	19.4	4	Sept. 9	13.6	6	Sept. 11	18.7	8	Sept. 14	18.4	11	.....	.....	.....
1879	Dec. 27	42.5	0	Dec. 30	37.3	3	Dec. 31	37.6	4	*Jan. 2	37.4	6	*Jan. 6	29.4	10	*Jan. 8	38.1	12	.....	.....	.....	.....	.....	.....
1880	Jan. 9	42.4	0	Jan. 12	37.0	3	Jan. 16	39.4	7	Jan. 16	41.9	7	Jan. 19	32.4	10	Jan. 22	41.3	13	Jan. 31	40.0	22	Feb. 1	—3.0	.....
1880	Feb. 16	53.2	0	Feb. 21	42.3	5	Feb. 23	42.4	7	Feb. 24	43.8	8	Mar. 2	33.3	15	.....	.....	.....	.....	.....	.....	.....	.....	.....
1880	Apr. 29	46.6	0	May 3	35.2	4	May 6	33.2	7	May 6	38.4	7	May 10	30.0	11	May 11	38.5	12	May 13	40.8	14	.....	.....	.....
1880	Dec. 8	37.2	0	Dec. 9	31.6	1	Dec. 11	32.0	3	Dec. 11	31.5	3	Dec. 14	23.9	6	Dec. 15	31.8	7	Dec. 19	31 9	11	Dec. 22	—6.5	.....
1881	Feb. 17	51.5	0	Feb. 19	38.7	2	Feb. 23	40.6	6	Feb. 24	42.6	7	Mar. 1	32.5	11	Mar. 5	41.8	16	Mar. 8	41.8	19	.....	.....	.....
1881	Apr. 17	41.9	0	Apr. 20	34.8	3	Apr. 20	38.6	3	Apr. 20	45.3	3	Apr. 28	34.4	11	May 5	43.7	18	May 11	41.6	24	.....	.....	.....
1882	Jan. 24	45.8	0	.....	.....	.....	Jan. 30	48.8	6	Jan. 31	47.6	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1882	Feb. 21	58.5	0	.....	.....	.....	Feb. 26	49.8	5	Feb. 26	49.8	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mean	.....	.....	.....	.....	.....	2.9	.....	.....	5.2	.....	.....	5.7	.....	.....	10.0	.....	.....	12.3	.....	.....	16.8	.....	.....	.....

LOWEST WATER.

1880	Feb. 10	14.3	0	Feb. 11	13.3	1	Feb. 11	14.8	1	Feb. 12	19.0	2	Feb. 12	14.9	2	Feb. 13	22.4	3	Feb. 17	27.3	7	Feb. 19	—6.1	9
1881	Jan. 2	6.8	0	Jan. 5	5.5	3	Jan. 8	5.5	6	Jan. 8	5.3	6	Jan. 10	2.4	8	Jan. 12	7.4	10	.....	.....	.....	Jan. 13	—7.0	15

*1880.

It is to be noted that the progress of the wave crest is dependent in great measure upon the height of water in the river, and becomes very irregular as the water reaches a high stand. In general the higher the water the longer is the time of movement, though there is on the whole a remarkable uniformity in the time of passage from one station to the next.

In the floods of 1882 it has been found impossible to trace wave crests to the lower Mississippi river owing to the uniform and continuous wave.

It may appear as if in the previous discussion too much weight has been given to the actual rainfall and not enough has been given to the rise produced by the melting of the winter's snow. The rainfall may be regarded as supplementing the melting snow, and in some years, especially in 1882, as almost entirely masking whatever influence may be due to it.

A rather interesting question arises incidentally in this connection, namely: Why may not the water-sheds of these rivers, containing many hundred thousand square miles, be regarded as an immense rain-guage with measuring scales at the various river gauges? The observations are not sufficiently extended as yet to admit of a very full discussion of the problem, but it would seem as though with some corrections we might obtain an idea of the relative rainfall from year to year over a large district much more completely in this manner than from the average of a few stations great distances apart. I have collected, mostly from the International Bulletin, all the daily records of rainfall at Cincinnati, Knoxville, Nashville, Saint Louis, Cairo, Memphis, and Vicksburg, from March, 1875, to May, 1882, in order to determine if possible the relation between sudden river rises, as well as great and extended ones, and actual rainfall for the two or three days preceding, but have not as yet carried the investigation far enough for a satisfactory result. The great difficulties in such a work may be seen from the fact that there are a very limited number of stations, and from the immense irregularity in the fluctuations of a river at different stages of water.

Turning, now, to the answers to the flood circular, it is proposed to introduce here only a few of the more prominent points, leaving a more extended statement for the full report.

First. Replies from the January flood on the Cumberland river.

Many of the replies from towns near the mouth of the river note the fact that while the river was steadily rising yet there were only light and infrequent rains in that region. Another reply states that, at the first rise, the water was perfectly clear, but at the second, a week later, it was very muddy. Nearly all the replies make particular mention of the fact that, contrary to the usual experience, the rise was exceedingly rapid, while the decline was correspondingly slow; the latter, in some districts, was a great advantage, however, as the losses sustained on houses and fences swept away was more than made up by the deposit of a heavy alluvion. Lands that heretofore have received large deposits of sand, at every overflow, are now heavily coated with rich soil, and the yield of these lands, many of them usually planted to corn, will give, with a fair season, an increase over the usual yield of from 15 to 20 bushels per acre. I find the following statement in one of the Nashville papers: "Hundreds of thousands of trees which, in the great flood of 1847, stood in the lowlands, have been cut down, thus giving wider scope to the backwaters." Also, one of the replies states that, "Were the banks as heavily wooded as in the great floods of 1824, the river would undoubtedly have risen some 10 feet higher than it actually did." It should be borne in mind, however, that applying precisely the same reasoning we may say that these heavily wooded banks higher up the river would have kept the waters from rushing directly to the river, and possibly "from a greater abundance of springs" (due to the same forests) "at that time," the flow of water would have been distributed over a much longer period, and the very high waters thus would have been avoided.

Losses from this flood were small, except in Davidson county, Tennessee, in which the losses, confined mostly to Nashville, were as follows. These estimates were carefully made by the state and county authorities:

Loss on land and buildings	$325,000
Loss on provisions and supplies	250,000
Loss on stock and implements	185,000
Loss on staple products	400,000
Total in county	1,160,000

Lumbermen, rivermen, and merchants estimate the loss at $1,500,000.

Second. The floods of the lower Mississippi river.

The following is a general statement of the loss of life and property in the counties bordering on the Mississippi, from Cairo to the mouth. These estimates are necessarily only approximate; frequently three or four observers in the same county have given estimates differing by $100,000, or even $200,000. The loss of life in nearly every instance is accompanied by the names of those lost:

East bank of the Mississippi river below Cairo.

TENNESSEE.

County.	Loss on property.	Loss of life.
Lake	$50,000	2
Lauderdale	15,000	1
Tipton	300,000	4
Total	365,000	7

MISSISSIPPI.

Tunica	$1,000,000	9
Bolivar	500,000	4
Washington	75,000	5
Warren	50,000	10
Jefferson	150,000	1
Wilkinson	12,000	2
Total	1,787,000	31

LOUISIANA.

EAST BANK.		
East Baton Rouge	$3,000,000	3
Ascension	150,000	1
Saint James	350,000	
WEST BANK.		
Carroll	200,000	7
Madison		2
Tensas	150,000	3
Concordia	900,000	About 15
Avoyelles	130,000	7
Pointe Coupée	563,000	20
West Baton Rouge	1,200,000	
Assumption	75,000	3
La Fourche	30,000	
Total	6,748,000	61

ARKANSAS.

Mississippi	$60,000	6
Crittenden	200,000	11
Saint Francis	75,000	2
Lee	200,000	5
Phillips	100,000	7
Desha	120,000	8
Total	755,000	39

Met. 8

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SIGNAL SERVICE NOTES NO. XVI.

THE EFFECT OF WIND-CURRENTS

ON RAINFALL.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY,

BY

G. E. CURTIS,
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WASHINGTON CITY:
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1884. Sept. 15.
Gift of
U. S. Signal Office
Washington, D.C.

NOTE.

The publication of this Signal Service Note is made for the purpose of bringing it to the attention of rainfall observers; the Chief Signal Officer does not thereby necessarily indorse the views herein set forth.

THE EFFECT OF WIND-CURRENTS ON RAINFALL.

The value of rainfall observations for the purposes of meteorology, climatology, and agriculture, depends upon the degree of approximation with which they represent the average rainfall over a considerable area. A single gauge can measure only the rain actually falling within its circumference, but, on the assumption that the amount collected by the gauge is a true measure of the precipitation, and that the distribution of rainfall is uniform, its records are taken as the average rainfall over the surrounding district. It is important, then, to know how far these conditions are realized, and how nearly the assumptions are justified.

As a matter of fact, the topography of the country, the position of the gauge with respect to buildings, and the direction of the wind, produce large variations in the amount of rainfall collected, and it is evident that the more local the disturbing influence the more restricted will be the significance which we can attach to the rainfall observations. It is desirable, then, to institute special comparative observations at as many stations as possible, for the purpose of ascertaining: 1st, the effect of local influences; 2d, the uniformity of rainfall over a considerable area; and 3d, the degree with which the records of a given position approximate to the average—thus determining completely the significance of the observations of a single gauge. The variation of rainfall of a gauge in any location, from the general average of many gauges in all positions, may thus be approximated, and, either a corresponding correction applied, or the record given a weight dependent on the value of the observations.

As an aid to such investigations it is the object of this paper to present: 1st, a brief historical summary of our present knowledge of the variations produced by wind in the *collection* of rain; 2d, some of the results of observations in different countries, showing the variations produced by wind in the *distribution* of rain; 3d, the results of special rainfall observations made at the Signal Service station on the summit of Mount Washington, New Hampshire.

I.

During the past fifty years the whole subject of rain collection has been investigated principally in connection with the question of the variation of the amount of rainfall at different elevations, in explaining which the most widely different theories have been proposed. It is only within the past few years that a final conclusion has been reached and the question, apparently, definitely settled. In the last century (1766) it was observed by Doctor Heberden that rain-gauges placed on the ground collect, in general, a larger amount of rain than gauges on roofs and towers. In lack of any satisfactory explanation of this variation, Doctor Heberden says: "It is probable that some hitherto unknown property of electricity is concerned in this phenomenon." Some years later, Benjamin Franklin, then in England, suggested that the increase of rain collected in gauges on the ground might be due to the augmentation of the rain drops by the condensation of moisture on their surfaces during their fall. Though this hypothesis was considered by Doctor Franklin himself to be inadequate and open to objection, it became, in later years, the generally accepted explanation of the phenomenon.

The subject continued to attract occasional attention both in England and on the continent,* but no decisive or generally accepted conclusion was arrived at.

In 1832, at the suggestion of the British Association and with a grant of money for the purpose, systematic observations were undertaken. As the result, Prof. John Phillips, who conducted the experiments, advanced as an explanation the same hypothesis that was suggested by Franklin in 1771, namely, that "the whole difference in the quantity of rain at different heights above the surface of the ground is caused by the continual augmentation of each drop of rain from the commencement to the end of its descent, as it traverses successively the humid strata of air at a temperature so much lower than that of the surrounding medium as to cause the deposition of moisture upon its surface."

That this theory is entirely inadequate to explain the phenomena was shown by Sir John Herschel, who demonstrated, mathematically, that the increase of a raindrop within the last few hundred feet of descent must be absolutely inappreciable.†

The first step towards a true explanation, supported by the results of observation, was made by Prof. A. D. Bache, of Philadelphia, in a report in 1837, to the British Association, entitled: "Note on the effect of deflected currents of air on the quantity of rain collected by a rain-gauge."

Prof. Bache made the important discovery that of four gauges placed at the corners of a roof, in general, the gauges to leeward received more rain than those to windward. From this discrepancy he was led to the belief that the effect of eddy-winds is a fact of primary consideration in the whole question of rain-gauge exposure.

No further advance of importance seems to have been made till 1861, when a complete theoretical explanation of the action of the wind in producing variations in observed rainfall was presented by W. Stanley Jevons in the Philosophical Magazine.

The importance of this memoir justifies us in making the following extract:

A stream of air, then, meeting an obstacle leaps over it; in so doing it is forced against the adjoining parallel stream of air, which must also diverge from the straight direction and similarly impinge upon the next stream.

But the increased pressure, produced by the impact, causes the streams of air to move more rapidly and to diminish in thickness at the same time; and the disturbance of the streams of air will cease at the point where the total decrease of size of the streams is equal to the height of the obstacle.

It is at least obvious than when a uniform wind meets an obstacle some parts of the air must move more rapidly, just as a river moves most rapidly in the narrowest parts of its channel.

It is quite in accordance, too, with our common experience that an obstacle increases the velocity and force of the wind; thus, the wind is always most fierce at the corner of a house, the end of a wall, or the summit of a hill.

We now have the whole explanation of the rain observations in question. A drop of rain in falling is influenced at once by gravity and the motion of the air. It describes the diagonal of a rectangle of which the perpendicular side represents the falling velocity of the drop, and the horizontal side the velocity communicated by by the wind.

Now conceive two equal drops of rain falling into a current of air at points where the velocity is not the same. They will not pursue parallel paths, but but the one drop will either approach to or recede from the other. The effect will be to increase or diminish the quantity of rain falling in the intermediate space.

To show clearly the nature of this effect we may imagine the stream of of air *M N* (Fig. 1) to be suddenly contracted at *B C* to half its previous

* Among others, see articles by—

Flaugergues, Bibl. Univ., VIII., 1818, p. 127; Annals of Phil., XIV., 1819, p. 113.

Meikle, Annals of Phil., XIV., 1819, p. 212.

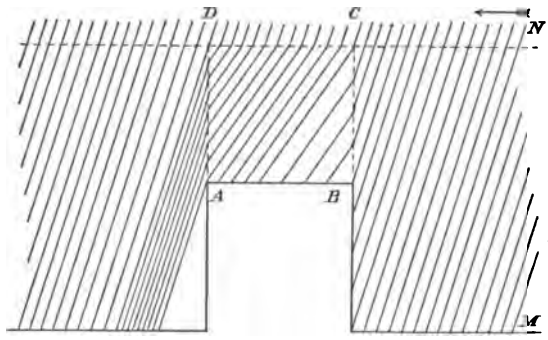
Boase, H. Annals of Phil., N. S., IV., 1822, p. 19.

Arago, Ann. Chim. et Phys. XVIII., 1821, p. 410; XXVII., 1824, p. 399; Poggend. Annal., XXIII., 1834, p. 417.

† See article on Meteorology, Enc. Brit., 8th Ed.

thickness, so that, of course, it must there commence to move with double velocity. At *A D* the stream dilates to its original size, and of course recovers its first velocity. The course of equidistant rain drops falling into wind under such imaginary circumstances would be represented by the oblique lines, and it is obvious that less rain would fall in the windward part of the contracted space than elsewhere.

FIG. 1.



To represent a real shower of rain falling upon an obstacle, we have only to conceive the drops of rain as falling through a great number of strata, all varying in velocity and thickness.

In view of the results of this memoir by Jevons the subsequent history of the problem, as presented by discussions in "British Rainfall" and the "Meteorological Magazine," during the next twenty years, is a most remarkable instance of neglect to profit by earlier investigations.

In an article in "British Rainfall" for 1866, the whole question is re-opened, and the reader is left at sea with the cheering information that "if we are still in doubt as to the *cause* of the decrease with elevation, we are no longer in much uncertainty as to its *amount*." In 1871, in the same publication, Rev. F. W. Stow, in a valuable article, showed graphically the influence of buildings in diverting rainfall during the prevalence of non-horizontal wind currents.

Comparative observations were now begun on an extensive scale. As the result of these Mr. G. Dines presented (see "British Rainfall," 1877) conclusions *almost identical* with those of Bache in 1838, and of Jevons in 1861, and in a re-discussion of the observations, by Rogers Field (see "Meteorological Magazine," 1878, vol. xiii.), additional confirmation was given in greater detail.

In the same year Symons recapitulated the discussion and published in full the article of Bache, which had been suffered to fall into oblivion. In a summary he says:

The terribly hard-fought battle, respecting the reason that a smaller quantity of rain is collected by rain-gauges elevated above the surface of the ground, is nearly settled, for the following points seem proved:

The greater part of the decrease is due to wind.

The stronger the wind, the greater the decrease with elevation.

The less the diameter of the elevated gauge, the less will it indicate.

A gauge on the leeward side of a tower may collect as much rain as one on the ground.

A gauge in the middle of a large roof may, notwithstanding its height, collect very nearly the same as one upon the ground.

In the following year, after a study of all available observations, Symons further concludes that "there is no evidence of any difference between the fall of rain at various heights from sixty feet to two hundred and sixty feet above the ground."

The last paper, a report by Symons to the British Association in 1881, reviews the discussion and concludes by saying that all recent investigations only confirm the results obtained by Bache and Jevons, with a few additional points that could have been directly inferred from their work.

In the investigation of the difference in rainfall with elevation above the ground the influence of buildings and the action of wind-currents have thus been ascertained, and the best exposure of gauges to secure average results has been determined.

In a résumé of the literature of this question, mention should also be made of an hypothesis first advanced by Prof. Phillips and again presented by Mr. Dalmahoy in 1862 (Trans. Roy. Soc., Edinburgh, vol. xxiii.), in which the decrease of rainfall with elevation is supposed to be due to the effect of downward currents of air that are set in motion by the falling raindrops. This ingeniously elaborated hypothesis was advanced because of the supposed inadequacy of the theory of eddy winds to explain the difference that Phillips and Arago reported to exist in times of calm, as well as the difficulty that, of three gauges at three different levels, the lowest gauge always receives more rain than the middle one, and the middle gauge more than the upper. Both these conditions seem to be shown, by the later investigations above quoted, not to exist, and, consequently, Mr. Dalmahoy's downward currents are not needed to account for the observed differences.

Numerous contributions to this subject have also been made by French meteorologists, of which the most noteworthy since the time of Arago are those of E. Renou.* In a communication to the Meteorological Society in 1863 he pointed out that the difference in the amount of rainfall collected at different heights depends not only upon the velocity of the wind but also upon the size of the drops. Large drops are less easily deflected by wind currents than small ones, and consequently give less variation in the amount of rain collected by different gauges.

II.

We now come to the second and larger question, namely: What variation in the distribution of rainfall due to wind is produced by the *topography* of the country? The practical problems have already been stated, namely: (1) to find over what area the record of a single gauge gives the average precipitation; and (2) to determine, from gauges at different stations, a law of variation, so that, given the observed precipitation at a few stations, the precipitation, for any other locality to which the law applies, can be computed. This is practicable only for those countries and districts where the rainfall, being dependent on regular and constant winds, the variations in precipitation are progressive and uniform.

The desirability of such determinations for southern India is pointed out by J. Allan Broun in "Trevandrum Observations," vol. i., and the following problems are specified as desirable matters of investigation:

1st. The law of rainfall along the coast, which diminishes from Cochin to Cape Comorin; 2d, the variation of the fall proceeding from the coast towards the mountains; and 3d, the variation with height on the Ghats with reference to coffee and other cultivation.

With these laws determined, Mr. Broun believed the number of stations in the above district might be reduced to eight.

Among the effects of the topography of the country on the distribution of rainfall the variations in mountain districts are especially noticeable, and it is to these we shall confine our attention. In general, the amount of rain increases with the elevation above sea-level up to a maximum plane, after which a decrease takes place. S. A. Hill has shown (see "Zeitschrift für Meteorologie," vol. xiv., 1879) that in the northwest Himalayas, where the rainfall is most remarkable in amount and rate of

*Renou, E.—Sur les quantités de pluie reçues par deux pluviomètres différant de hauteur ou de dimensions. Ann. Soc. Mét. de France vol. xi., 1863, pp. 69–73; Sur les quantités de pluie recueillies à deux niveaux différents; *idem*, vol. xiii., 1865, pp. 162–163; vol. xxvii., 1879, p. 109.

Haeghens, J.—Sur les observations pluviométriques faites a deux niveaux différents pendant 32 années consécutives, de 1817 à 1848. Ann. Mét de France, vol. iii., 1851, pp. 155-158.

Goulier, C. M.—Influence de la position d'un pluviomètre sur la quantité de pluie qu'il indique. Bull. Inter. de l'Observatoire de Paris, April, 1864.

Dausse—Sur les quantités de pluies reçues par pluviomètres à des hauteurs différentes. Ann. Soc. Mét. de France, xxvii., 1879, pp. 89–92.

Maille, P. H.—Nouvelle théorie des hydrométéores, p. 278, Paris, 1853.

Paris, Service hydrométrique, Manuel hydrologique du bassin de la Seine. Paris, 1884.

variation, the observations can be represented by the following empirical formula:

$$R \text{ (amount of rain)} = 1 + 1.92h - 0.40h^2 + 0.02h^3$$

in which h is the relative height in units of 1,000 feet above an assumed plane which is itself 1,000 feet above sea-level. From this formula the height of maximum rainfall is computed to be 3,160 feet above the plane, or 4,160 feet above sea-level. It is further shown that this elevation is that at which, according to the observed law of decrease of temperature, the southwest monsoon is cooled just below its dew-point. This point will be that at which, in the mean, we should expect the maximum precipitation to take place. The results obtained from the empirical formula thus receive a theoretical and deductive confirmation. In the following volume of the "Zeitschrift" (vol. xv., 1880, p. 373), Hann has collected observations from stations on the Arlberg, in the western Tyrol, by which the plane of maximum rainfall is shown to be at a somewhat higher level in that region than in India. The highest station, at an elevation of 5,900 feet, has the maximum rainfall. A very rapid diminution takes place on the leeward side, where the stations record only about half the amount of rainfall given by stations of equal altitude on the windward side.

The "Report upon the Rainfall of Barbados," by Governor Rawson, giving the results of observations from 1847 to 1871, shows a similar variation with altitude; the amount of rain increases regularly with the height of station except in a few localities where the law is masked by other local causes of variation.

The explanations offered for this increase of rainfall with altitude above sea level have been as various and as ingenious as those for the decrease of rainfall on towers and buildings, reviewed in the first part of this paper. The first explanation offered was designed especially to account for the rains on the Himalayas, and was to the effect that a certain stratum of the southwest monsoon contains a greater quantity of moisture than the other strata and therefore gives a maximum precipitation. This hypothesis was rendered untenable by the actual observations of Hooker and Strachey, which showed a steady diminution of vapor-tension with increase of altitude. A discussion of these observations by Strachey (Proceedings of the Royal Society, March, 1861,) together with a later investigation by Hann ("Zeitschrift für Meteorologie," vol. ix., 1874,), who derives a formula for the decrease of vapor with altitude, have greatly increased our knowledge as to the distribution of aqueous vapor in the upper parts of the atmosphere.

A second explanation was that the contact of the moist air with the cold surface of the ground, on mountain sides and hill tops, produces the increased precipitation. In answer to this supposition it may be said that only the air within a short distance of the ground is cooled in this manner. But, as it has been already shown that the lower strata of the air give no appreciable rainfall, this hypothesis is inadequate to explain the increase that must be accounted for. Other similarly insufficient explanations, such as that of the mixing of warm and cold air, have been advanced.

The real cause is undoubtedly to be found in the cooling of air by expansion, whereby vapor-laden wind-currents, forced to ascend mountains or elevated plateaus, expand against surrounding atmospheric pressure and are cooled below the dew-point, so that their moisture is precipitated. This principle explains the fact, already mentioned, that the plane of maximum rainfall in the northwest Himalayas is that at which, by the law of diminishing temperature, an ascending current of vapor would be cooled down to the dew-point, whereupon precipitation must ensue.

III.

The preceding examples of the variation of rainfall on mountain slopes in India, Europe, and the West Indies, with the individually varying results that have been found, show the necessity of numerous comparative observations in all mountainous districts if we expect to obtain any accurate knowledge of rainfall distribution.

The large rainfall recorded at the Signal Service station on the summit of Mount Washington has seemed particularly worthy of careful study and special observations have been undertaken. The first point of investigation has been relative to the distribution of rain on the summit itself, since it seemed probable that the enormous wind velocity experienced there might produce sensible inequalities, both in the gauge readings and in the actual rainfall, wherefore the records of a single gauge would not present average results for the whole summit.

From September 1, 1882, to October 1, 1883, comparative observations were made daily with four extra gauges, placed seventy-five feet north, south, east, and west of the station gauge (see map of summit, Plate I.). These gauges were cylindrical, fourteen inches deep, and surmounted by a small receiving cup, three inches in diameter.

As the observer reported that the measurement of snow is altogether unreliable for comparative purposes owing to the velocity of the wind, the observations used in the following discussion will be those of rainfall only. The result of this series of observations is given in the following table, I., containing the rainfall only during the thirteen months of observation; the records of each gauge are first tabulated according to the direction of the wind:

TABLE I.—*Rainfall, excluding snow, September, 1882–September, 1883, inclusive, on Mount Washington.*

	A	B	C	D
NE.....	1.48	1.31	1.47	1.43
E.....	.18	.15	.18	.16
SE.....	1.24	2.69	1.87	1.65
S.....	4.33	8.28	6.91	6.40
SW.....	3.29	4.20	3.85	3.71
W.....	4.92	5.13	4.02	3.70
NW.....	29.15	28.23	26.31	24.93
N.....	1.23	1.20	0.79	0.65
Total...	45.82	51.19	45.40	42.63

Location of extra gauges: A, 75 feet south of station gauge; B, 75 feet east of station gauge; C, 75 feet north of station gauge; D, 75 feet west of station gauge.

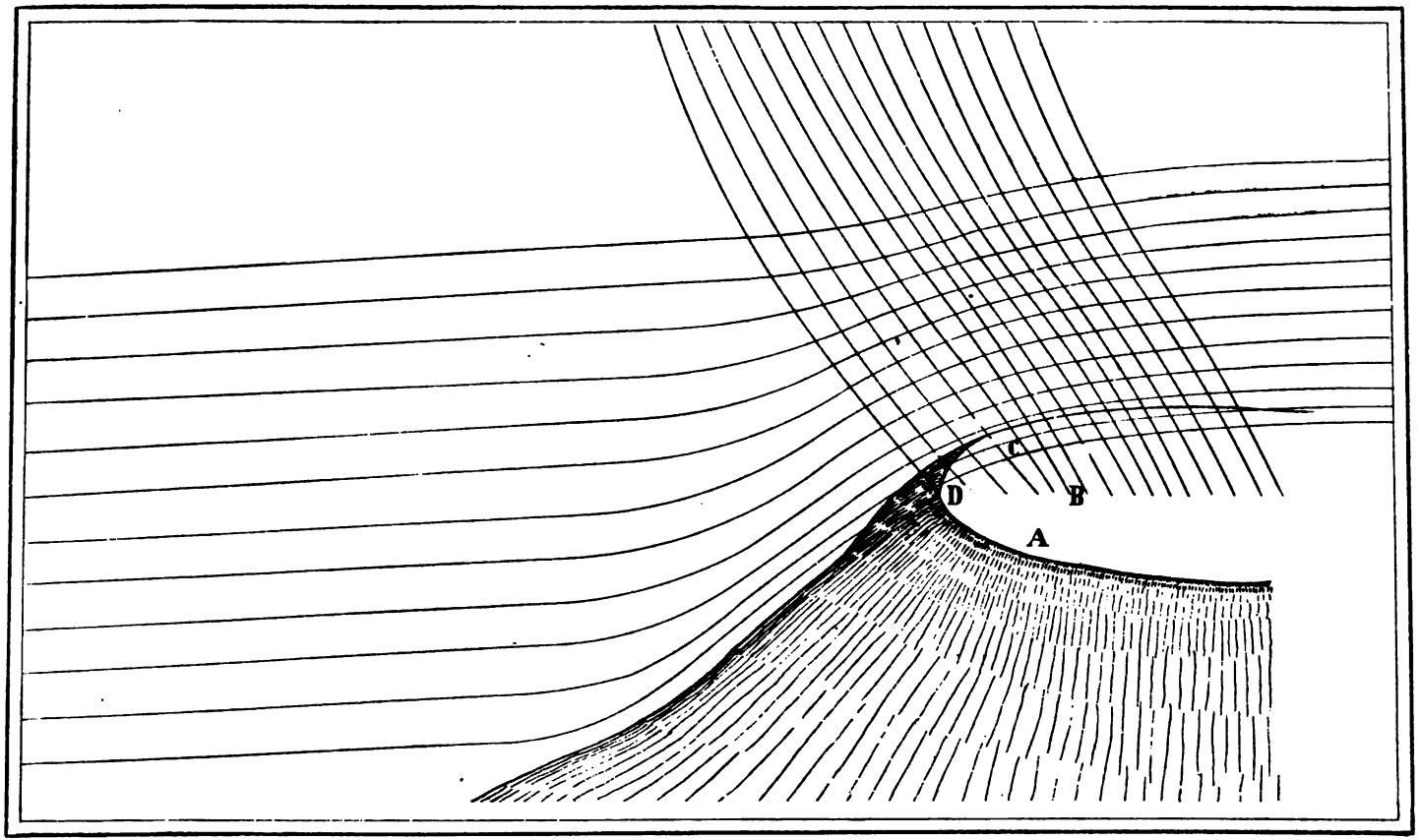
This table exhibits discrepancies in the total amounts of rain collected in the several gauges, apparently too large to be attributed to errors in collection and measurement. The first result obtained from the observations is, then, that the *precipitation varies materially within distances of only one or two hundred feet.*

The law of the variation is next to be sought for. By arranging the figures of the preceding table according to the relative location of the gauges to windward or leeward, as in the following table, the law of variation is rendered apparent:

TABLE II.—*Showing the rainfall in windward and leeward gauges.*

Wind.	Windward gauges.	Central gauges.	Leeward gauges.
N	C 0.79	B 1.20 D 0.65	A 1.23
NW	C 26.31 D 24.93		A 29.15 B 28.23
W	D 3.70	A 4.92 C 4.02	B 5.13
SW	A 3.29 D 3.71		B 4.20 C 3.85
S	A 4.33	B 8.28 D 6.40	C 6.91
SE	A 1.24 B 2.69		C 1.87 D 1.65
E	B 0.15	A 0.18 C 0.18	D 0.16
NE	B 1.31 C 1.47		A 1.48 D 1.43

PLATE II.



THE EFFECT OF WIND UPON THE DISTRIBUTION OF RAIN ON MOUNTAIN SUMMITS

It will be seen that with a few exceptions, to be noted hereafter, the windward gauges record the least rain, the central gauges somewhat more, and the leeward gauges the most of all. This result is in accordance with the law of variation of rainfall on the roofs of buildings stated, as we have seen, by Bache, in 1837. Unless the agreement is accidental, we may conclude, therefore, that the wind acts in the same way in affecting the distribution of rain on the summit of Mount Washington as when obstructed by buildings and towers.

The action of wind currents in producing this increase of rain to the leeward may be illustrated by the accompanying figure (see Plate II.), based on the theory of Jevons, already stated.

Let *A*, *B*, *C*, *D*, be the location of four gauges on the summit of a mountain, *C* being the northern, and *A* the southern gauge, and suppose the horizontal lines to represent westerly wind currents. On reaching the mountain the lines are crowded together and forced upward over the summit and laterally around the mountain sides; the figure representing only those forced upward. The velocity of the wind thus obstructed in its course is largely increased. The course of equidistant raindrops falling under an increasing velocity of the wind will be represented by the intersecting lines. On the windward side of the summit, near the surface of which the wind has attained its highest velocity, the rain is carried over and past the gauges there located and precipitated to the leeward, where the wind has regained a portion of its original velocity. Thus the gauge *D*, situated to the windward during west winds should receive the least rain, *A* and *C* a larger amount, and *B* the most of all. The relative locations of the extra gauges on Mount Washington correspond with the positions above given and the gauges should therefore present these differences. Turning now to the preceding table, we find for west winds $D = 3.70$, $A = 4.92$, $C = 4.02$, $B = 5.13$. A result agreeing exactly with the requirements of the hypothesis. Table II. contains, however, a few apparently discordant results that must receive a separate examination. A portion will thus be found to be exceptions that prove the rule, or, rather, that show how it is modified by other considerations.

1st. The rainfall in gauge *D* during north winds and in gauge *B* during south winds, the former giving the smallest record and the latter the largest record, are two such exceptions.

If now we turn to Plate I, which shows the exact location of the gauges, *B* will be seen to be one hundred and fifty feet nearer the central north and south line of the summit than *D*. Of wind currents, those that strike the mountain near the center will be deflected upward, while those striking the mountain nearer to either side will be deflected laterally and pass *around* rather than *over* the summit. An increased precipitation should accordingly be expected over the locus of the augmented wind-current. Thus, with northerly and southerly rain-bearing winds *B* should receive more rain than *D*, and we find this to be the case. *A* and *C*, being in a direct north and south line, conform as they should to the law of increase to the leeward.

2d. With an east wind, for which we have only one rain storm, the several gauges record almost the same amounts with but a few hundredths variation. This equable result is explained by the anemometer record, which registers, during this storm, a velocity of but about ten miles an hour, being only one-third of the average velocity for the month, As variations are due to the wind, it is evident that the smaller its velocity the smaller will be the variations between the readings of the gauges.

3d. A single prominent exception to the principles above stated is found in the excessive record of gauge *B* as compared with *C* during southeast winds. For the location of our gauges we have found with other winds that the rainfall increases to the leeward, yet at some point a maximum must be reached, beyond which a decrease takes place; so for southeast winds it may be that the gauge *C* is beyond the point of

maximum precipitation. The rainfall with easterly winds is, however, so small that the differences due to the locations of the gauges for these winds cannot sensibly affect the monthly or annual totals.

The average of the four gauges gives the following percentages for the amount of rain falling during winds from different directions:

NE.	E.	SE.	S.	SW.	W.	NW.	N.
.03	.00	.04	.14	.08	.10	.59	.02

By far the largest part of the whole rainfall is thus shown to occur with northwest winds. We should, therefore, expect that gauge B, which is to leeward with respect to northwest winds, and nearer to the centre of the summit than A, would present the largest annual record of all the four gauges, if the principles above stated be correct. The totals of Table I. show this to be the case.

In the preceding discussion the records of the station gauge, having a receiving surface eight inches in diameter, have not been included, owing to the fact that its measurements were found to be uniformly much greater than those of the three inch gauges. The total amount of the station gauge, covering the same periods as the totals of the four extra gauges given in Table I., was 58.70. This excess, occurring with winds from all directions, is to be explained by a difference in the collection arising from the difference in the sizes and patterns of the two styles of gauges. From the above observations, however, the portion of the variation due to the peculiarities in the gauges can not well be separated from the variation dependent on a difference of location.

During July, 1883, a series of observations was made with the station gauge and a three inch gauge in which the latter was placed a short distance from the station gauge and located so as to be under, as nearly as possible, the same influences. In this series of observations the differences due to location and environment are as far as possible eliminated, and a direct comparison of the two gauges in collecting rain can be secured. Table III. gives these observations arranged according to the velocity of the wind:

TABLE III.—*Giving results of comparative readings of eight inch and three inch gauges.*

Wind velocity (miles per hour)	15		40		60		75	
	3 in.	8 in.	3 in.	8 in.	3 in.	8 in.	3 in.	8 in.
Amount of rain	1.75	1.84	2.77	3.37	1.60	2.44	1.87	3.49
Percentages	100	105	100	122	100	152	100	186

The following empirical formula, obtained from the above results, represents the observations with a sufficiently close approximation, $\frac{G_8}{G_3} = 1 + .015x^2$ in which G_8 and G_3 are the amounts collected by the eight inch and three inch gauges, respectively, and x the velocity of the wind in units of ten miles per hour.

The discrepancy between the measurements of the two gauges varies, therefore, directly as the *square of the velocity of the wind*, and is due to insufficient collection by the smaller gauge.

By means of this formula the totals of the small gauges given in Table I. can now be rendered comparable with the total of the station gauge.

The average velocity of the wind during rain was, as nearly as can be determined, about forty-five miles per hour. For this wind velocity the formula gives thirty per cent. as the factor by which the totals of the three inch gauges must be increased in order to correspond to the station record. The totals of the gauges will then be $A = 59.57$, $B = 66.55$, $C = 59.02$, $D = 55.42$, station $= 58.70$. In this system of values the station record agrees with the law of distribution of rainfall already obtained.

The deductions from the two series of observations are thus, as far as they go, confirmatory of each other.

The large difference, above found, in the collection of rain by the two sizes of gauges does not agree with the observations of English and Continental meteorologists. After collecting all available data relative to the question, Prof. H. Mohn, Director of the Meteorological Institute of Norway, made a special report to the International Meteorological Congress held at Rome in 1879, in which he says: "From the foregoing facts it is evident that the size of the receiving surface exerts no influence as long as the diameter does not sink below three English inches." Whereupon the Congress reversed the decision, made at Vienna in 1873, by passing the following resolution: "The Congress thinks that for stations of the second and third order, a diameter of eight or even four inches is sufficient for the rain gauge."

This accordance, observed by Symons and Mohn, between the records of three inch and larger gauges is probably due to the fact that the observations were made only during relatively small wind velocities, in general not exceeding twenty miles per hour, and the average of which was probably less. If this was the case, Prof. Mohn's decision in no way affects our conclusion that, for stations with very high winds, the three inch gauge gives insufficient records and that the deficiency varies with the square of the wind velocity.

The results obtained from the above observations confirm the statement made at the outset of this paper, and in illustration of which this investigation has been undertaken, namely, that special comparative observations are necessary if we are to have any accurate knowledge of the significance to be attached to rain-gauge records, and of their value as meteorological and climatological data.

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SIGNAL SERVICE NOTES NO. XVII.

A FIRST REPORT

UPON

OBSERVATIONS OF ATMOSPHERIC ELECTRICITY

AT

BALTIMORE, MARYLAND.

PREPARED UNDER THE DIRECTION OF

BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,

CHIEF SIGNAL OFFICER OF THE ARMY,

BY

PARK MORRILL,

PRIVATE, SIGNAL CORPS, U. S. ARMY.

BY AUTHORITY OF THE SECRETARY OF WAR.

WASHINGTON CITY:
SIGNAL OFFICE.
1884.

SIGNAL OFFICE, WAR DEPARTMENT.

U. S. — SIGNAL SERVICE NOTES NO. XVII.

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WASHINGTON CITY:
SIGNAL OFFICE.
1884.

1885. Mar. 6,
Gift of
The Signal

NOTE.

The scientific importance of observations of atmospheric electricity is generally conceded, although their practical value to the meteorologist is still problematical. Possibly the addition of lines of equi-potential to our tri-daily weather maps may contribute to the successful prediction of the advance of thunder-storms and tornadoes. With this in mind, in 1882, I ordered three selected men of the Signal Corps, in addition to their other duties, to devote themselves to the study of atmospheric electricity and cognate subjects, under the guidance of Professors Rowland and Trowbridge, of Johns Hopkins and Harvard Universities, respectively. These gentlemen, and the institutions with which they are connected, have given gratuitously every needful facility for the prosecution of this work and have made most gratifying reports of the progress and ability of the students. I have therefore purchased the necessary apparatus and have established, at Baltimore and Cambridge, special electrical stations of the Signal Service, hoping that others will be established when the success and usefulness of these are well ascertained. The present note, by Private Morrill, gives the first results of the observations at Baltimore and is published as an earnest of future work in that field.

W. B. H.

LETTER OF TRANSMITTAL.

JOHNS HOPKINS UNIVERSITY,
Baltimore, Md., June 27, 1884.

CHIEF SIGNAL OFFICER, U. S. ARMY,
Washington, D. C.,

SIR: I have the honor to transmit herewith, at Professor Rowland's suggestion, a report upon the apparatus established here, by your direction, for the observation of atmospheric electricity, and of which I was directed to take charge in letter dated O. C. S. O., October 6, 1883. This report is preliminary to a more complete study of the record obtained. It considers the defects found in the apparatus and the difficulties met with in its use, and also embodies the results indicated by a preliminary study of the record obtained for the months of March and April. It is hoped the work done will meet with your approval and may be found useful in determining the methods of future work in this subject.

Very respectfully,

PARK MORRILL,
Private, Signal Corps.

PRELIMINARY REPORT UPON OBSERVATIONS OF ATMOSPHERIC ELECTRICITY.

In the latter part of November, 1883, apparatus for the observation of atmospheric electricity was sent to the Johns Hopkins University, from the Chief Signal Officer, and put in my charge, under the supervision of Professor Rowland. This was of the self-recording form employed by M. Mascart, at Paris, and, except for certain defects in its mechanical construction, has worked in a satisfactory manner. It was placed in position during the early part of December and a record, beginning with December 15th, has been obtained, except for a few days, the sheets for which were destroyed in development.

The University authorities kindly provided a room for my use in what was formerly a dwelling-house but is now used by the University for laboratory purposes. This is No. 187 N. Howard street, and is in the northwestern part of the city, on ground about one hundred and ten feet above sea-level. The electrometer and recording instrument were placeed in a front room upon the third floor, and the collector was placed at the fourth-story hall-window, at the rear of the house, looking west. This window overlooks a large yard and affords a fairly free exposure for the collector. The nozzle of the collector is 34 feet 3 inches above the ground and nearly one hundred and forty-five feet above sea-level. The windows of the room containing the electrometer and recording instrument were covered with heavy curtains to exclude light while changing the photographic sheets and adjusting the apparatus. These instruments were also placed in a dark closet, to obviate keeping the room always darkened.

APPARATUS.

The apparatus consists of a quadrant electrometer, of the form designed by M. Mascart; a clock moving a vertical slide, which carries the sensitized paper for a photographic record; a dark lantern with lens and slit; a battery of fifty zinc-copper water cells for charging the quadrants of the electrometer; and a water-dropping collector.

As received, the clock would not run at all and had to be taken to pieces and some of the parts refitted. The slide carrying the sensitized paper would not move steadily and spoiled the record. This was remedied by grinding the slide and its track together with emery. The lantern sent with the apparatus, had an open burner designed to use a solution of turpentine in alcohol, but, with the purest articles obtainable, it would not burn steadily twelve hours. A light was desirable which would continue steady for twenty-four hours without attention, as it was impossible to replace the lamp, after moving it, so as to avoid causing an irregularity in the record. A small kerosene burner with chimney, was first substituted for the open burner but, although better than the latter, would not burn steadily for a full day. Moreover, any arrangement requiring the presence of a lamp in the closet which contains the electrometer, is objectionable, as the products of combustion render the air moist and injure the insulation of the needle and quadrants of the electrometer. Hence the lantern was removed entirely and a kerosene lamp, placed outside the closet and before a slit, was substituted. This has worked perfectly and will give a light of steady brightness for more than thirty-six hours.

The electrometer, when first set up, was charged with the whole battery of fifty cells, one pole being connected to each pair of quadrants and the middle of the battery to earth. The bifilar suspension fibres were separated less than an eighth of an inch. With this adjustment the instrument apparently worked well during

the month of January. At the beginning of February the deflections of the needle became less, and it was at last evident that the insulation was defective. The glass rods supporting the binding-screws had also been loosened in their sockets by use. On February 23d the electrometer was taken apart; the fastenings of the rods were tightened, the rods dried by flame and the silk-covered wires connecting the quadrants were removed and naked ones substituted. Separate binding-posts, mounted on glass rods kept dry by sulphuric acid, were made, to which those of the electrometer were permanently connected in order to avoid again loosening the latter. The sulphuric acid was renewed in the cup of the electrometer and the insulators holding the wire which connects the collector and electrometer, after these had been carefully washed and dried. This refitting was completed February 26th, and when the instrument was again started the deflection of the needle threw the beam of light entirely off the recording sheet. To render the electrometer less sensitive the suspension fibres were separated more widely from day to day until March 4th, when they were as far apart as the construction of the instrument would permit—nearly a half inch. The beam still being off the sheet very often, the battery was reduced on March 16th from fifty to thirty cells. This adjustment, the threads fully separated, and the battery of thirty cells, was employed during the remainder of March and April. The beam of light was still thrown off the sheet occasionally, and on April 30th the battery was reduced to ten cells. With this adjustment the light is seldom off the sheet, and the instrument has worked very well. The only fault now is a failure of the needle to return quite to the same zero after a deflection of long duration. This seems due to a defect in the manner of its suspension. The readings of the electrometer since the refitting of February 23–25th, have been many times larger than those before that time, which fact seems to indicate an insufficient insulation in some part of the instrument up to that date.

The collector was frozen during nine days in December, January, February and March. It has also been stopped several times by dirt getting into the nozzle.

The photographic paper, of French manufacture, sent with the apparatus, did not develop clearly, nearly every sheet having dark blotches, and the curve frequently fading during the fixing of the print. The supply of this paper was exhausted March 9th, and a paper made by the Scovill Company of New York was used during the rest of March and April. This gave much better results; the prints are very clear but the colors of the sheets are not uniform, and the gelatine surface has a tendency to blister during development. The most satisfactory paper found is one made by the Photographic Artists Co-operative Association of London. This gives very clear black prints on a nearly white ground which seldom shows dark blotches, and there is no tendency to blister.

Graduation.—The sheets were graduated at frequent intervals by disconnecting the electrometer from the collector and then connecting it first to one and then to the other pole of the same battery used for charging the quadrants. But, since the latter has been reduced to ten cells the remaining forty have been used for graduation, first one pole and then the other being connected to earth, which gives a difference of eighty cells. A larger battery of several hundred cells should, however, be provided for this purpose, as the potential of the atmosphere is sometimes a thousand volts above that of the earth and often five hundred.

Defects.—The worst defects of the apparatus are to be found in the construction of the recording instrument and the use of the water-dropping form of collector.

There is much disadvantage in having a separate sheet for each day's record. Time is lost in changing sheets and adjusting the instrument, and with this form of day-register the record cannot be made exactly true as to time. A recording instrument should be made so as to use a long roll of paper, and should have a chronographic attachment to record time upon the sheet with precision.

The water-dropping collector could not be used in any colder winter than ours, and gives much trouble here. Even in warm weather it is frequently choked by dirt in the water. The varying height of the water causes changes in the rate of flow, which make the instrument more sensitive at one time than another. A mechanical system of moving conductors would obviate these difficulties.

STUDY OF RECORD.

A preliminary study of the record sheets, obtained up to the end of April, gives the following results:

The work of December must be considered experimental in the establishment of the apparatus and the sheets for December 15–28th have no value. No satisfactory lamp was secured during this time. The sheets for December 29–31st and January 1st are missing, as the recording instrument was taken apart during this time for grinding the slide and arranging the lamp outside the closet in place of the lantern. From January 2d to 6th the collector was frozen most of the time. The sheets for January 7–9th were ruined in development.

From January 10th to February 23d the record is complete except that the sheet for February 20th was destroyed in development. These sheets have a value as indicating the character of changes in the electrical condition of the atmosphere, but from the much greater deviations of the needle after the readjustment of February 23–25th we must conclude that quantitatively they are of but little importance. February 23d to 25th the apparatus was down for repairs.

Since February 26th, when the record is resumed, the indications of the electrometer are to be regarded as correct, but, owing to its too great sensitiveness, the curve is only found at intervals upon the sheets until March 4th. From this time the record is satisfactory in every respect and is nearly complete. The sheets for March 14th and 19–22d were spoiled in development. These sheets were of the Scovill paper and had to be hardened to prevent blistering. This was done before fixing the print and the result was to ruin them. The sheets for April 26–29th are missing, as the paper ordered could not be obtained in time, being out of stock.

With these exceptions a complete and satisfactory record has been obtained since March 4th. Therefore a special study has been made of the record for the months of March and April. The method pursued is as follows: The curves disclose, upon examination, continuous fluctuations occupying but a few minutes and ranging in value from ten to hundreds of volts. In comparing the electrical variations with other meteorological elements, we have no observations of the latter, approximating in frequency these changes. Moreover, it is improbable that any continuous meteorological record of these elements would show variations of such frequency. I therefore drew a smoother curve whose fluctuations occupied not less than an hour. Then, from the empirical graduation of the sheets, scales were made with the electromotive force of a zinc-copper water cell as unit, and the value, in such units of the potential of the atmosphere was measured for each hour of each day. These were tabulated, and from the data so obtained a continuous curve was drawn, on a suitable scale, its abscissæ representing time and its ordinates, the atmospheric potential. Curves with corresponding abscissæ were drawn for the various meteorological elements. The curves that give promise of useful comparative study are those of temperature, humidity, rain and wind. The barometric variations are far too long in duration and seem to have no direct relation to the electrical changes. Similarly, with respect to varying cloudiness, there are the same continuous fluctuations of the needle on a perfectly clear day as with passing clouds or complete cloudiness. Copies of the curves of electric potential, dry and wet bulb temperatures, rainfall, direction and velocity of wind, made on ferro-prussiate paper, are transmitted herewith. A comparison of these curves shows:

1. There were during March and April fifteen rains of considerable amount, viz.: March 5th, 7–8th, 9th, 14th, 19th, 23d, 26th; April 2d, 8th, 9th, 13th, 15th (2), 16th, 25th. Of these, thirteen are preceded by a fall in potential of from 150 to 1,000 cells. This fall begins from two to twenty hours before the commencement of rain, and, except in rain of March 7th, extends to the beginning of the rainfall. The curve of potential is missing for comparison with the rain of March 19th. Only the rain of April 16th is preceded by a rise in potential.

There are also twelve slight rains of less than 0.02 inch, eleven of which are preceded by a fall in potential and the curve of potential is missing for the remaining one on April 23d. Hence, we conclude that rain is preceded by a falling potential.

2d. During the time when no rainfall occurs, there are several periods of northwest winds, viz.: March 29–31st; April 3–6th, 10–12th, 16–17th. During such wind, the potential curve is nearly the reverse of the velocity curve of the wind, maxima of wind corresponding to minima of potential. We also find, during March and April, ten cases where the wind veers through the east, viz.: March 5th, ne.–se.; 10th, n.–se.; 18th, n.–se.; April 1st, nw.–se.; 12th, nw.–se.; 20th, n.–se.; 22d, ne.–s.; 23d, ne.–s.; 24th, n.–se.; 30th, n.–se. All these, without exception, are accompanied by a rise in potential. There are also six cases of its backing through the east, viz.: March 5th, se.–ne.; 26th, se.–ne.; April 2d, se.–ne.; 21st, se.–n.; 23d, s.–ne.; 24th, se.–ne. Five of these are accompanied by a fall in potential. The sixth occurs during the rainfall of March 26th.

There are seven calms recorded during the period considered, as follows:

March 4th, wind comes up from ne. potential falls.
March 15th, wind comes up from sw. potential falls.
March 17th, wind comes up from s. potential rises.
March 23d, wind comes up from w. potential falls.
March 24th, wind comes up from e. potential rises.
March 28th, winds comes up from n. potential falls.
April 7th, wind comes up from n. potential falls.

From these facts—the variation of potential with the velocity of a northwest wind, the rise of potential as the wind veers from north to south, its fall as the wind backs from south to north, and its rise or fall after a calm, according as the wind comes up from a southerly or a northerly direction—there seems an indication that north (to west) winds are accompanied by a low potential; south (to east) winds by a high potential—should such a law be established it will have a most important bearing upon the theory of atmospheric electricity.

3d. During the snows of April 8th and 9th, there are remarkable oscillations of the needle, extending far beyond the record. Similar oscillations were during the snows of January. These rapid oscillations of the needle have, I think, been characteristic of every snow-storm.

Tantochronous observations.—During the study of these curves, one fact has become very manifest. This is the necessity, in order to a successful meteorological study of atmospheric electricity, of a coincident series of self-registered observations of the other meteorological elements. This should be not only a coincident series but one similar in respect of time spaces upon the record-sheets, and the time should be recorded upon all by the same clock, so that the most minute fluctuations can be precisely compared. Such a series of observations seems possible by photographic registration. A photographic record of this sort has been obtained by me, for the barometer pressure, since April 20th, upon the sheets containing the potential curve. This record has proved quite satisfactory and by a modification of the construction of the barometer, could be made entirely so. I think the record of dry and wet-bulb thermometers could be added at no great expense, and possibly observations of wind and clouds.

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SIGNAL OFFICE, WAR DEPARTMENT.

SIGNAL SERVICE NOTES NO. XVIII.

THE AURORA IN ITS RELATIONS TO METEOROLOGY.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY,

BY
ALEXANDER McADIE,
PRIVATE, SIGNAL CORPS, U. S. ARMY.

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NOTE.

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THE AURORA IN ITS RELATION TO METEOROLOGY.

An auroral display is, at the present time, very generally explained to be an electrical manifestation in the high atmospheric regions. The source from which the energy, thus manifesting itself, is derived, is a matter of conjecture as yet; while the effects of its dissipation have not received any important attention or study, although the value of an auroral display, as a weather prognostic, offers an inviting field for discussion. The origin of the auroral energy, on the other hand, is none the less interesting, for it involves not alone the manner of acquisition of an electrical charge by the atmosphere, but also the conditions of the different meteorological elements at the times when this acquisition is in progress. If we believe that the aurora is a manifestation of atmospheric electricity, we shall expect to find that it has some significance as an exponent of the condition of the atmosphere, if not elsewhere, at least in the immediate vicinity of the display. Our knowledge of the electrical phenomena of the atmosphere is quite limited, but what there is, together with the strong general similarity in behavior and appearance, confirms our belief in the electrical nature of the aurora.

Professor Lemström, passing an electrical current through air, and continuing its passage through rarified air, has obtained a luminous appearance which closely resembles the aurora. He has argued from this that an electrical current passing through the atmosphere at ordinary pressure would give no indication of its presence until it reached regions less dense, where a discharge would then occur, and such a discharge as modified by the surroundings would appear to us as an aurora. The ability of the air to hold an electric charge diminishes as the pressure decreases and as the temperature increases. When the pressure is reduced to about 3 mm. of mercury, any further reduction will increase rapidly the ability of the air to retain a charge, and a much greater electromotive force is necessary to produce a discharge than would be required in air at atmospheric pressure. The condition of the atmosphere as regards density, would then materially affect the appearance of the aurora if it be, as is assumed, a manifestation of the electricity resident in the atmosphere.

In the winter of 1881–2, Lemström put his theory to a practical and seemingly a very successful test. By covering the hill side of Oratunturi with uncovered copper wire, which at intervals had discharging points, and through which a powerful current was passing, the peak of the hill at night was surmounted with a pale yellow or blue light, of faint intensity, yet so far as could be determined, identical with the auroral light. None of the neighboring peaks were thus surmounted. (This experiment was repeated in the following winter by Tromholt, without success.) We class the aurora then among those atmospheric phenomena which have an electrical origin, and place it with lightning and phosphoresent clouds, as a display of atmospheric electricity, differing because of the modified conditions under which, in each case, the discharge occurs. The object of this paper is to trace to some extent the possibility of this relationship, and from the data at hand to search for some connection between auroral displays and meteorological conditions.

It will be necessary to know the geographical distribution of auroras, the characteristic meteorological conditions of localities where auroral frequency is a maximum or minimum, and the physical principles brought into operation in the acquisition and dissipation of an electrical charge in the atmosphere.

Kämtz first charted the curves of equal auroral frequency, and subsequently both Fritz and Loomis tabulated the geographical distribution and mapped out the zones of equal frequency. Fritz gave the name of *isochasmen* to these lines of equal auroral frequency. The isochasmen as thus determined are not absolutely but only approximately true, for the data on which they were based were often scattered and uncertain; and further, it has been lately shown that the aurora itself is a variable phenomenon, and dependent for its production upon conditions that are themselves variable in time and place of occurrence. Even the most reliable records are imperfect again, inasmuch as the only method of determining the presence of an aurora is visibility, and auroral displays may and frequently do occur in the day time or when the sky is clouded over. According to Fritz's chart the zone of maximum frequency, starting from the south of Greenland, passes through Labrador, and crossing the parallel of 60° N. at about the middle of Hudson's Bay, passes through the Great Bear Lake and leaves Alaska just south of Point Barrow. It crosses the parallel of 70° N. and skirts northern Asia, following the shores of the Arctic. It then runs northwesterly and crosses the parallel of 75° N. at 135° E. from Greenwich, reaching its most northerly point (76° N.), and thence southwesterly, touching Norway and crossing the parallel of 70° N. at 20° E. from Greenwich. It then continues southwesterly and crosses the parallel of 60° N. at 20° W. from Greenwich, reaching its most southerly limit (about 57° N.) over the northern middle Atlantic. The other isochasmen are in the main parallel to the one of maximum frequency. At the equator auroras are unknown, and south of 40° they are very rare. Above the zone of maximum frequency the number of auroral appearances decreases, and all Arctic expeditions, penetrating north of this zone to any extent, report a diminished frequency and brilliancy, and further that the plane of occurrence is in the southern part of the heavens; the further north they are, the further south the aurora appears to occur. At the middle latitudes the frequency of auroral displays increases rapidly as one moves northward, and at a rate out of all proportion to the latitude increment, showing, therefore, that some other cause than increase in latitude is required to account for the irregular geographical distribution. Fritz's chart (which is given on the opposite page) shows also that the isochasmen are independent of the magnetic meridians, and in themselves are unsymmetrical and irregular, and apparently without any close relationship to other physical conditions. They extend further southward over water surfaces than when over land surfaces. Fritz pointed out, also, that, while the isochasmen did not exhibit as close an agreement with the isoclinics as we would expect, there did seem to be a relation to the isobaric curves of Schouw, the regions of lowest pressure being the regions of maximum auroral frequency.

The frequency of auroral appearance in the different portions of the United States is approximately shown by the following tables:

Thunder-storms and Auroras in the United States.

NOTE.—First line of figures at each station gives the number of thunder-storms, and the second line number of auroras.

Place.	1881.							1882.						
	July.	August.	September.	October.	November.	December.	Total for year ending December, 1881.	January.	February.	March.	April.	May.	June.	Total for year ending June, 1882.
Albany, N. Y.	5	3	6	0	0	0	18	0	0	0	0	1	5	20
	0	0	3	0	0	0	5	0	0	1	2	0	0	5
Alpena, Mich.	7	3	7	3	0	0	29	0	0	1	2	9	7	30
	0	0	6	2	1	3	21	1	2	1	8	3	2	29
Atlanta, Ga.	4	3	3	1	0	0	21	0	1	1	3	0	6	22
	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Thunder-storms and Auroras in the United States—Continued.

Place.	1881.							1882.						
	July.	August.	September.	October.	November.	December.	Total for year ending December, 1881.	January.	February.	March.	April.	May.	June.	Total for year ending June, 1882.
Augusta, Ga	5	2	3	0	0	1	23	0	0	2	4	5	5	27
	0	0	1	0	0	1	2	0	0	0	2	0	0	4
Baltimore, Md	2	3	2	0	1	0	19	0	0	1	1	1	4	15
	0	0	0	0	0	0	0	0	0	0	3	0	0	3
Bismarck, Dak	0	1	0	0	0	0	8	0	0	0	2	4	4	11
	1	1	3	0	3	2	14	1	1	1	4	2	3	22
Block Island, R. I	3	1	0	0	0	0	6	0	0	0	0	0	3	7
	0	0	0	0	0	0	0	1	2	0	1	0	0	4
Boisé City, Idaho	0	0	0	0	0	0	6	0	0	0	1	1	1	3
	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Boston, Mass	2	2	3	0	0	0	7	0	0	0	0	0	2	9
	0	0	2	0	0	0	2	0	0	0	1	3	0	0	6
Brownsville, Tex	0	0	0	0	0	0	2	0	0	0	0	1	1	2
	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Buffalo, N. Y	2	2	3	2	1	0	15	0	0	1	3	0	5	19
	0	0	1	0	0	2	8	0	1	0	1	0	1	6
Burlington, Vt	12	4	7	0	0	0	29	0	0	0	0	0	5	28
	3	0	7	4	0	1	37	2	2	5	10	3	6	43
Cairo, Ill	1	2	5	2	2	0	40	0	3	4	5	9	8	41
	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Campo, Cal	3	4	0	0	0	0	10	0	0	0	1	0	0	7
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Camp Thomas, Ariz	6	0	0	0	0	0	8	0	0	0	0	0	4	10
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cape Henry, Va	3	2	0	0	0	0	16	0	0	0	2	1	0	8
	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Cedar Keys, Fla	13	4	4	0	0	0	30	0	0	0	1	2	3	3	30
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Champaign, Ill	4	1	3	0	1	0	14	0	0	0	2	3	2	6	22
	0	0	1	0	0	0	1	0	0	0	0	1	0	6	8
Charleston, S. C	3	1	4	0	0	0	13	0	0	0	1	1	2	10	22
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charlotte, N. C	8	2	0	1	0	0	29	1	1	1	5	7	5	31
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chattanooga, Tenn	6	2	7	1	0	1	40	0	1	2	4	3	13	40
	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Cheyenne, Wyo	8	8	2	0	0	0	33	0	0	0	0	3	11	32
	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Chicago, Ill	7	1	5	0	1	1	26	1	0	2	6	1	9	34
	0	0	0	1	0	0	1	0	0	0	1	0	0	2
Cincinnati, Ohio	3	3	1	1	0	0	24	0	0	3	4	8	8	31
	0	0	0	0	0	0	0	0	0	0	3	0	0	3
Cleveland, Ohio	4	0	3	1	0	0	17	0	0	0	2	2	8	22
	0	0	1	0	0	0	1	0	0	1	0	1	0	3
Davenport, Iowa	5	3	6	2	0	1	31	0	0	0	2	5	3	13	40
	0	0	2	0	1	0	3	0	0	0	0	2	0	1	6
Dayton, Wash	1	2	1	0	0	0	4	0	0	0	0	1	0	0	4
	0	0	1	0	0	0	2	0	0	0	1	1	0	1	4
Deadwood, Dak	.....	.....	.....	.....	.....	.....	.....	0	0	0	1	1	1	1	.....
	.....	.....	.....	.....	.....	.....	.....	0	0	0	1	1	0	0	.....
Decatur, Tex	1	0	0	0	0	1	12	0	1	1	2	1	4	11
	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Delaware Breakwater, Del	0	2	0	1	0	0	5	0	0	0	0	1	0	2	6
	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Denison, Tex	2	1	0	0	1	0	23	0	3	1	4	3	4	19
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver, Colo	4	2	0	0	0	0	15	0	0	0	0	1	1	3	11
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Des Moines, Iowa	6	4	8	2	1	0	43	0	1	5	4	3	11	45
	0	0	0	0	1	0	1	0	0	0	1	0	0	2
Detroit, Mich	7	0	2	1	0	1	20	0	0	0	1	1	1	6	19
	1	0	1	0	1	1	6	0	0	0	2	1	0	0	6
Dodge City, Kans	6	8	4	4	0	0	28	0	0	1	0	1	1	3	28
	0	0	0	0	0	0	0	0	0	0	0	1	0	0	41
Dubuque, Iowa	11	5	11	3	0	1	49	0	0	0	3	5	2	8	49
	0	0	2	1	2	0	7	1	0	0	0	3	0	2	19
Duluth, Minn	3	6	3	1	0	0	18	0	0	0	0	1	2	3	19
	1	2	2	0	1	2	15	0	0	0	0	4	1	1	23
Eagle Pass, Tex	2	2	5	2	0	1	22	0	1	0	0	0	10	3	6
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eagle Rock, Idaho	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eastport, Me	4	9	0	1	0	0	7	0	0	0	0	0	4	18
	2	1	6	3	0	3	24	3	2	0	2	3	1	3	29
El Paso, Tex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Thunder-storms and Auroras in the United States—Continued.

Place.	1881.							1882.						
	July.	August.	September.	October.	November.	December.	Total for year ending December, 1881.	January.	February.	March.	April.	May.	June.	Total for year ending June, 1882.
Erie, Pa	1	1	1	0	0	0	5	0	0	2	0	0	3	6
	0	0	1	0	1	1	3	0	0	0	3	1	0	7
Florence, Ariz	3	4	0	0	0	0	7	0	0	0	1	0	0	8
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fort Apache, Ariz	4	6	1	3	0	0	18	0	0	0	1	0	2	17
	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Fort Assinaboine, Mont	0	0	0	0	0	0	.....	0	0	0	0	4	3	7
	0	0	0	0	3	7	.....	2	2	0	4	0	1	19
Fort Bennett, Dak	0	3	1	0	0	0	14	0	0	0	2	4	4	14
	0	0	2	0	2	1	6	0	0	0	2	0	0	8
Fort Benton, Mont	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	2	0	2	1	11	0	1	0	0	0	0	9
Fort Buford, Dak	4	1	0	0	0	0	15	0	0	0	0	1	4	10
	0	0	0	0	0	1	5	0	0	0	1	0	0	8
Fort Custer, Mont	0	0	0	0	0	0	0	0	0	0	0	1	2	3
	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Fort Elliott, Tex	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fort Gibson, Ind. T	0	3	3	2	3	1	18	1	4	3	5	7	.....	*34
	2	0	0	0	0	0	0	0	1	0	3	0	.....	*3
Fort Grant, Ariz	10	10	2	3	0	0	29	0	0	0	0	0	8	33
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fort Keogh, Mont	1	1	2	0	0	0	11	0	0	0	0	2	3	9
	1	0	0	0	0	0	2	0	0	0	3	0	0	4
Fort Missoula, Mont	1	3	0	1	0	0	10	0	0	0	0	1	3	9
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fort Stevenson, Cal	1	1	0	0	0	0	7	0	0	0	0	0	3	5
	1	1	2	0	1	4	13	0	1	0	3	1	0	14
Fort Saint Michael's, Alaska	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	1	3	4	4	29	2	6	2	3	0	0	25
Grand Haven, Mich	4	4	4	1	0	0	19	1	0	0	3	1	1	5
	2	0	1	0	0	3	7	1	1	0	5	0	0	13
Helena, Mont	0	0	0	0	0	0	0	0	0	0	0	4	1	5
	0	0	0	0	1	3	2	0	0	0	2	0	1	5
Indianapolis, Ind	5	3	4	0	1	1	27	0	0	0	6	3	4	20
	0	0	1	0	0	0	1	0	0	0	2	0	0	3
Jacksonville, Fla	16	7	0	1	0	0	44	0	0	1	4	16	13	60
	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Key West, Fla	4	4	10	0	0	0	25	0	0	0	0	3	0	21
	0	0	0	0	0	0	0	0	0	0	1	0	1	2
Knoxville, Tenn	8	8	3	0	0	0	45	1	1	1	4	8	14	48
	0	0	0	0	0	0	0	0	0	0	1	0	0	1
La Crosse, Wis	4	4	4	1	0	0	20	0	0	2	1	2	9	24
	0	0	2	0	2	0	6	2	0	0	5	0	0	11
Leavenworth, Kans	2	2	6	1	1	0	35	0	2	1	5	2	8	30
	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Little Rock, Ark	1	0	2	0	0	1	4	0	1	3	7	8	3	26
	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Los Angeles, Cal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lynchburg, Va	6	2	4	1	0	0	22	0	0	1	5	5	12	35
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Madison, Wis	6	3	4	2	0	0	27	1	0	2	3	3	6	30
	1	0	1	0	1	1	7	0	0	0	3	0	1	8
Marquette, Mich	2	5	4	0	0	0	17	0	0	0	1	1	2	15
	0	5	3	2	0	3	13	0	1	1	6	3	2	21
Memphis, Tenn	4	2	2	1	2	0	46	2	5	3	6	9	3	39
	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Milwaukee, Wis	6	1	7	2	0	0	26	1	0	2	2	2	8	30
	0	0	1	0	0	0	1	0	1	0	1	0	1	4
Mobile, Ala	5	2	2	1	1	3	31	0	1	2	6	3	2	32
	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Moorhead, Minn	3	6	0	1	0	0	15	0	0	0	0	0	2	17
	0	0	1	0	1	0	4	1	0	1	5	0	3	11
Mount Washington, N. H	6	2	6	1	0	0	23	0	0	0	0	0	2	17
	0	0	3	1	0	1	8	1	1	2	3	1	4	17
Nashville, Tenn	5	5	2	1	2	0	39	0	1	4	5	4	10	39
	0	0	1	0	0	0	1	0	0	0	2	0	0	3
New Haven, Conn	3	3	2	0	0	0	13	0	0	0	2	0	3	10
	1	0	2	1	0	0	7	1	0	1	3	1	0	15
New London, Conn	7	1	0	0	0	0	12	0	1	0	0	1	5	15
	0	0	2	0	0	0	3	1	0	0	1	0	1	5
Newport, R. I	5	1	2	0	0	0	12	0	1	0	1	0	4	14
	1	0	1	2	1	6	7	2	1	1	3	0	0	18
New York City	2	1	1	0	0	0	7	0	1	0	1	0	2	8
	0	0	0	0	0	0	0	0	1	0	2	0	0	3

Thunder-storms and Auroras in the United States—Continued.

Place.	1881.						Total for year ending December, 1881.	1882.						Total for year ending June, 1882.
	July.	August.	September.	October.	November.	December.		January.	February.	March.	April.	May.	June.	
Norfolk, Va	5	1	1	0	0	0	18	0	0	0	4	2	4	17
	0	0	0	0	0	0	0	0	0	0	2	0	0	2
North Platte, Nebr	4	2	3	1	0	0	22	0	0	0	3	3	6	22
	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Olympia, Wash	0	1	0	0	0	0	2	0	0	0	0	0	1	2
	0	0	0	0	0	0	0	0	0	0	2	1	0	3
Omaha, Nebr	4	3	2	3	0	0	40	0	0	1	6	4	6	29
	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Oswego, N. Y	5	2	5	1	0	0	19	0	0	0	0	0	15	28
	0	0	1	0	3	1	8	1	0	2	3	1	1	13
Pensacola, Fla	8	6	3	0	1	12	46	0	2	1	6	4	6	49
	0	0	0	0	0	0	0	0	0	0	1	1	0	2
Philadelphia, Pa	1	0	0	1	0	0	13	0	0	0	2	1	7	12
	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Phœnix, Ariz	1	2	0	0	0	0	3	.....	.....	.....	.....	.....	.....	.....
	0	0	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
Pike's Peak, Colo	5	1	0	0	0	0	24	0	0	0	0	2	1	9
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pioche, Nev	6	0	0	1	0	0	10	0	0	0	0	1	2	10
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pittsburg, Pa	10	1	4	2	0	0	30	0	0	1	2	2	4	26
	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Port Eads, La	5	6	1	1	0	2	.....	0	2	1	5	1	1	20
	0	0	0	0	0	0	.....	0	0	0	0	0	0	0
Port Huron, Mich	4	2	4	1	0	0	15	0	0	1	3	0	4	19
	0	0	1	0	1	1	5	1	0	0	1	0	1	0
Portland, Me	3	1	1	0	0	0	9	0	0	0	0	0	2	7
	1	0	0	0	0	1	2	1	0	1	3	1	0	8
Prescott, Ariz	13	12	2	2	0	0	49	0	0	0	1	3	3	36
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Punta Rasa, Fla	8	12	9	1	0	0	47	0	1	0	2	4	6	43
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rochester, N. Y	2	3	1	1	0	0	11	0	0	2	4	1	3	16
	0	0	2	0	0	2	8	3	1	1	1	0	1	12
Roseburg, Oreg	1	0	0	0	0	0	2	0	0	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sacramento, Cal	0	0	0	0	0	0	3	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Saint Louis, Mo	7	4	5	3	1	1	58	0	2	6	4	6	12	51
	4	0	0	0	0	0	0	0	0	0	2	0	0	2
Saint Paul, Minn	2	6	2	1	0	0	21	0	0	1	1	2	5	20
	2	0	1	0	1	0	6	1	1	0	3	0	3	12
Saint Vincent, Minn	11	3	3	0	0	0	35	0	0	1	0	0	3	21
	1	6	5	3	2	5	50	3	4	3	10	2	2	46
Salt Lake City, Utah	8	6	1	1	0	0	22	0	0	0	0	3	3	22
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Diego, Cal	0	0	0	0	0	0	.....	0	0	0	0	0	0	0
	0	0	0	0	0	0	.....	0	0	0	0	0	0	0
Sandusky, Ohio	4	1	4	1	0	0	20	0	0	3	1	2	8	24
	1	0	1	0	0	0	3	0	0	0	1	0	0	3
San Francisco, Cal	0	0	0	0	0	0	1	1	0	1	0	0	1	3
	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Savannah, Ga	1	1	2	0	0	0	16	0	0	3	3	1	7	18
	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Sitka, Alaska	0	0	0	0	3	4	.....	4	2	0	0	0	0	13
	0	1	1	4	3	4	.....	2	1	8	6	3	0	33
Springfield, Mass	4	3	5	2	1	2	42	0	3	6	4	9	14	53
	0	0	1	0	1	0	2	0	0	0	0	1	1	4
Thatcher's Island, Mass	0	1	0	0	0	0	1	0	0	0	0	0	6	7
	0	0	0	0	0	0	0	2	1	2	2	0	2	9
Toledo, Ohio	5	0	7	2	0	0	25	0	0	1	1	2	12	30
	1	0	1	0	0	0	3	0	0	0	1	0	0	3
Tucson, Ariz	1	1	2	2	0	0	8	0	0	1	0	1	5	13
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Umatilla, Oreg	1	1	1	0	0	0	8	0	0	0	0	0	3	6
	0	0	1	0	0	0	3	0	0	1	3	0	0	5
Washington City	7	3	4	0	0	0	19	0	1	1	3	1	2	22
	0	0	0	0	0	0	0	0	0	0	4	0	0	4
Yankton, Dak	6	2	4	3	0	0	23	0	0	1	1	2	5	24
	3	0	3	0	2	0	8	0	0	0	2	0	0	10
Yuma, Ariz	1	2	0	0	0	1	7	0	0	0	0	0	0	4
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number of thunder-storms	340	291	265	86	23	33		14	45	105	204	229	510	
Total number of auroras	24	12	83	27	41	63		36	29	39	197	27	59	

It will be seen at once that the annual frequency for a given locality is by no means constant. Newport, R. I., New York, N. Y., Mount Washington, N. H., Moorhead, Minn., La Crosse, Wis., Fort Benton, Mont., Champaign, Ill., Boston, Mass., Block Island, R. I., and Bismarck, Dak., all show marked differences in the yearly number of auroras reported as occurring at those places. Some allowance, especially in the case of large cities, must be made for errors of observation. A luminous appearance of the northern sky may be mistaken for an auroral display, and on the other hand a true aurora of no great altitude might easily be hidden from the observer's view by interposing buildings or other objects. With such exceptions these tables show that in the middle and southern plateau regions, the Rio Grande valley, and the Gulf states auroral displays are at a minimum. East of the Rocky mountains, between the parallels of 30° and 40° N. latitude, the number of auroras seen during the year averaged less than five. North of 40° the number increases very rapidly and unevenly. In the lake regions, Saint Lawrence valley, and northern portion of the New England states the average number seen during the year amounted to over thirty. The geographical features of the country seem also to influence the frequency of both auroras and thunder storms. Proximity of water surface, especially in land water surfaces, seems to increase the number of auroral displays, as is shown by the increase in the neighborhood of the great lakes, while in mountainous districts, on the other hand, the number is diminished. Thus, we find at Augusta, Georgia, the elevation above sea-level being 180 feet, three auroras were recorded, while at Atlanta, at an elevation of 1,100 feet, no auroras were recorded. Similarly, at Mount Washington, N. H., at an elevation of 6,279 feet, the number of auroras seen in the year might be recorded as twelve, while at Burlington, Vt., at an elevation of 268 feet, the yearly auroral frequency is about forty. So the geographical features of a locality may influence to some extent the frequency of auroras at that place, but of themselves do not explain the general distribution.

We shall first examine the characteristic meteorological conditions of these places in which auroral displays are at a maximum and at a minimum. The three prime factors entering into the meteorological condition of any place are pressure, temperature, and humidity; and with all of these combined, as well as with each separately, must the condition of the atmosphere at any place, with regard to its electric charge, be considered.

The general pressure distribution over the globe may be described as made up of certain permanent areas of high and low pressures. In winter, for the northern hemisphere the distribution of these pressure areas is a "low" over the north Atlantic, roughly between 20° and 70° W. from Greenwich and 45–90° (?) N., and a "high" area over central Asia, roughly between 40–60° N. and 90–110° E. from Greenwich. Balancing this "high" on the other side of the "low" over the northern Atlantic, there is another "high" in the western part of the United States, say between 36–55° N. and 100–120° W. The minimum of pressure is to the southwest of Iceland, and subordinate minima are found also in Davis Straits and midway between Jan Mayen and the Lofoten Isles. In summer this distribution is materially modified, and we find the area of greatest "low" now over Asia (an area in which the mean pressure may be taken as 29.50 or 750 mm., whereas during the winter the mean pressure for the same locality would be about 30.70 or 780 mm.), extending from 40–120° E. from Greenwich and from 30–65° N. latitude. The "low" which in winter was over the Arctic and northern Atlantic, extends southward and now covers the whole northern half of the Atlantic. For the whole globe the annual pressure distribution may be described as made up of five belts; at the equator and to some distance on both sides a belt of relatively "low," over the temperate climates belts of relatively "high," and beyond the parallels of 62°, extending towards

the poles, belts of "low." The southern of these polar lows is noteworthy, because, as far as we know, it remains almost fixed and does not vary with the seasons.*

Comparing this annual mean pressure distribution with the annual mean frequency of auroral displays, it is plainly apparent that with the exception of the equatorial parts, the low-pressure areas cover the places of maximum auroral frequency. Not only are the isochasmen somewhat similar to the isobaric curves, but where the pressure is least the auroral frequency is greatest. The two distinct areas of greatest "low" within the polar belt of "low," are just south of Iceland, and again over the northern Pacific around Alaska. At just these places, it will be noticed, the isochasmen bend down and widen out, while on the other hand, over northern Asia the zone of maximum auroral frequency contracts, and here the "low" belt is less extended and constant. From this correspondence, which can not be supposed accidental, we would suppose the isochasmen to be functional to pressure distribution rather than dependent on the position of the magnetic pole. We have further, in support of such a relationship between pressure distribution and auroral frequency, the interesting facts, lately developed by both Weyprecht and Tromholt, relative to the periodic oscillations of the isochasmen. The isochasmen are not constant, as have been previously said, but swing northward and southward with the seasons. The auroral belt, as it is called, or in other words the zone of maximum frequency, reaches a most southerly point about the autumnal equinox; then traveling northward to reach its highest northern location about the time of the winter solstice, moving south again until the vernal equinox, and then returning again northward with the summer.†

For auroras observed in Europe, Kämtz in his meteorology determines the mean monthly frequency to be as follows:

January, 229; February, 307; March, 440; April, 312; May, 184; June, 65; July, 87; August, 217; September, 405; October, 497; November, 285; December, 225, and Loomis, for auroras observed in America, gives the mean of the records for 113 years as January, 173; February, 210; March, 240; April, 267; May, 191; June, 177; July, 244; August, 238; September, 293; October, 236; November, 215; December, 159.

For the single year, which was taken in the tables previously given, the monthly frequency of auroras observed in the United States was:

January, 36; February, 29; March, 39; April, 197; May, 27; June, 59; July, 24; August, 12; September. 83; October, 27; November, 41; December, 63.

There is a decided increase then in the number of auroras occurring in the months of April and September in America, and March and October in Europe. Or, it is evident the maximum auroral frequency for these countries occurs at the equinoxes, which are, as far as pressure distribution is concerned, transition periods. The minimum number of auroral displays occur about mid-summer, with a second minimum about mid-winter. Leaving these general correspondences, however, we come to the consideration of more special instances, where conditions of pressure distribution can be more directly compared with the presence or absence of auroral displays.

For the year 1881–2, the pressure conditions for each month and the relative frequency of auroral displays were briefly these. In July 1881, the section of country having a mean atmospheric pressure of 30.0 inches (or 762.0 mm.) included the lower and part of the upper Mississippi valleys, with the eastern Gulf and south Atlantic states, or more generally, the region bounded by a line starting from the coast at Charleston, running northwestward to Chicago, then westward to Omaha, and thence southward to Indianola, Texas. This was the region of "high." The "low" area was in the Saint Lawrence valley and northern New England districts,

* See article on meteorology in Ency. Brit. † Nature, June, 1882.

the mean pressure there being 29.85 inches (758.1 mm.). Another area of "high" existed in the extreme north Pacific region. During the month there were two widely observed auroral displays, the line of visibility running in the first from Sidney, N. S., westward to Bismarck, and thence northward to Duluth; and in the second, which was probably the continuation of the first, from Eastport westward to Yankton. Of the 24 reported auroral appearances for the whole country, during the month, 8 were recorded in New England from four stations; 14 in the northwest (*i. e.*, Michigan, Minnesota, Dakota and Montana) from nine stations, and 2 from Ohio.

In August the area of 30.0 had moved to the east and northeast, and increasing in extent now covered the Southern states, except Florida, the Ohio valley and middle Atlantic states, and the upper lake region, or roughly, a district bounded by a line starting from Boston, running westward to Rochester, and thence northwestward out of the United States, running southward from Marquette to Cairo, bending easterly to Nashville, and thence south to Mobile and eastward to Savannah. No well-marked "low" is to be found in the United States, the lowest pressure being in the Missouri valley and Texas. There were no great auroral displays during the month, such displays as were reported being local and limited in extent, and a minimum number occurs during the month. Of the 12 reported displays, 8 occurred in Minnesota, 2 in Dakota, 1 in Maine, the other in Alaska. The number of thunder-storms was large and especially so in the Missouri valley and Texas.

In September a marked change had taken place in the positions of the different pressure areas. The area of 30.0 is confined to a narrow section of the lower Mississippi valley, and northeastward through the Ohio valley, lower lakes, and Saint Lawrence valley. To the east of this the pressure is higher, the whole Atlantic seaboard north of Charleston, having a mean pressure of 30.1. The "low" areas are in the upper Mississippi and Missouri valleys, the mean pressure there being 29.9 (759.4). Bordering the south Pacific coasts is another "low," and on the northern Pacific coast an area of "high." With such a pressure distribution, the thunderstorm frequency should be greater than the average in the Missouri valley, while the auroral frequency should likewise be above the average in the lake region, upper Mississippi valley, and northwest. The reported auroral displays and thunder storms were as had been anticipated. On the 12th, 13th, and 14th of the month, there was a great magnetic storm, and as a consequence or accompaniment, remarkably brilliant and extensive auroral displays. On the 23d an extensive auroral display occurred, while other extensive displays occurred on the 20th, visible from Halifax to Alpena, and on the 28th, visible from Maine to Michigan. Of the eighty-three recorded auroral appearances, twenty-four were reported from New England, the rest being almost entirely reported from the upper Mississippi and Missouri valleys and the northwest.

In October the area of "high" covered the middle Atlantic, part of the southern states and the Ohio valley, the pressure being about 30.15 (765.7 mm.), diminishing on all sides, the lowest pressure being in the Canadian Maritime Provinces, the area of low which in September was over the upper Mississippi valley having moved further east. There was but one general auroral display which, however, was of some duration. On the 16th and 17th this display was visible from Sidney, N. S. westward to Dakota, and on the 18th visible only in the lake region. Local displays, *i. e.*, those not visible at many places at the same time, were characterized by their slight altitude and nearness to the horizon. There were only twenty-seven reported auroral appearances (seven of which were reported from Alaska), and of these, seven were reported from Michigan and Minnesota and twelve from New England. That is, with the movement of the low easterly, there seems to have been a decrease in the auroral frequency of the locality over which it had been prevalent in the preceding month.

In November the low pressure areas (in which the pressure happened to be about 30.0) were over Lake Superior and the eastern Canadian Maritime Provinces; while that which had been the "high" in October had been intensified (30.20) and contracted slightly in a southerly direction. An important auroral display occurred on the 23d which was visible from Oswego to Montana and southward to Iowa. The time of visibility appears to have moved slightly south of its position in the previous month. Forty-one displays were recorded, their distribution varying; for the stations in Montana and Dakota, two; for those in Minnesota, over one; for Wisconsin and Iowa, the same for New England, one.

In December the areas of lowest pressure were in the northern Canadian Maritime Provinces and in northern Minnesota, the pressures being about 30.0. The area of highest mean pressure for the month was in the southern states (being 30.2), and in the country west of the Missouri valley and western Gulf states. The line of visibility of any extended auroral display, we would expect to find stretching eastward from Marquette along the lake region and Saint Lawrence valley. Auroral displays during the month were indeed quite numerous though not particularly brilliant in this region. The following displays of wide extent were recorded: on the 8th from Eastport west to Fort Buford, Dak.; on the 9th and 10th also; on the 23d from New Brunswick westward to Idaho, continued on the 24th and 25th. There were various individual pressure area movements at the times of these displays which may be noticed in passing. The 8th and 9th an area of "high" was journeying over Ohio and towards the north Carolina coast, while at the same time an area of "low" was travelling from the lake region into New Brunswick; and on the 10th the centre of a second "high" followed closely the first, was nearing the Atlantic coast. Again, on the 23d an extended "high" was moving towards the coast, the centre of highest pressure being in the Ohio valley on the 24th, and in the middle Atlantic states on the 25th. Both auroral displays before mentioned, show close connection in their place and time occurrence with the movements of the pressure areas. During the month there were sixty-three auroras reported and but thirty-three thunder-storms. The agreement between frequency of thunder-storms and movements of great pressure areas first pointed out by Dr. Meldrum, as exemplified in the case of the thunder-storms in Mauritius and the pressure areas of Asia, finds confirmation in the case of the thunder-storms of the United States. During the month of November, December, and January, we have a minimum number of thunder-storms, and it is just at this time of the year that the country over which they are most likely to occur is covered by one of the great areas of high pressure; while equally true on the other hand, we find our maximum number of thunder-storms to occur at times when the "high" of the winter has given place to the "low" of summer.

For January, 1882, the "low" areas were found in the Lake Superior region and in the Canadian Maritime Provinces, the pressure being in the neighborhood of 30.0; while in the south Atlantic states and in the middle plateau region, areas of "high" pressure existed, the mean pressure being about 30.2. The "low" of December then in the upper Mississippi valley had moved eastward slightly. Three widely observed displays were recorded during the month, that of the 19th being visible in an almost continuous line from Halifax to Bismarck, and that of the 14th from Cape Breton Island eastward to Dakota. Of the thirty-six reported auroral appearances fourteen were from New England, Minnesota and Dakota having only six, and the northern part of New York four.

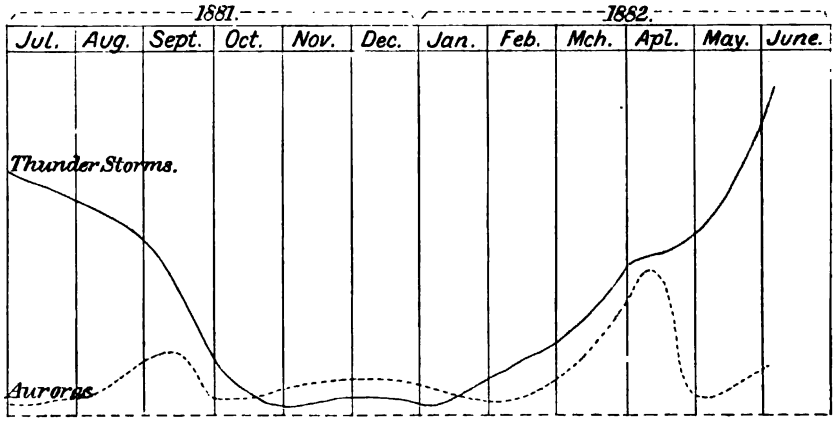
In February the southeastern quarter of the country is in an area of "high," the southern states having a mean pressure of 30.2. The low areas of the preceding month have not changed much in position, the mean pressures of the upper lake region and eastern half of the Canadian Provinces being slightly in excess of 30.0.

An auroral display on the 17th was observed from Sidney, N. B. westward to places in the upper lake region. Only twenty-nine auroral appearances were recorded, of which ten were from New England, nine from Minnesota and Michigan (and nine from Alaska).

In March, the low area north of the lake region in February had moved northeasterly out of the country; the lowest mean pressure was northeast of New England, and the highest in the southern states, the whole distribution not varying greatly from the preceding month, excepting the northerly movement of the "low." Auroral appearances were slightly in excess of the previous month, the line of visibility of the one widely observed aurora running from Eastport westward to Umatilla, Oregon.

In April quite a difference in the pressure distribution as compared with preceding months is noticeable. The lowest mean pressure was over Arizona, New Mexico, and Colorado, with a second "low" in the north Atlantic, extending westward to the Saint Lawrence valley. The highest mean pressure occurred over Lake Superior and Minnesota, extending to the south and southeast. Auroral displays were unusually frequent and extensive, one hundred and ninety-seven auroral appearances being recorded. Exclusive of a great magnetic storm on the 16th and succeeding days, other extensive displays occurred. Places in the districts between the "high" in Minnesota and the northwest on one side, and the "high" over the south Atlantic states, exhibit a marked increase in the number of auroras seen. Thus Cincinnati, which had no auroras during the rest of the year, had three visible in this month. Indianapolis which reported but three during the year has two in this month, and likewise Pittsburg, Erie, Toledo, Louisville, Saint Louis, Chicago. Davenport and Detroit,

In May there was no great change in the position of the pressure areas, the eastern part of the country being nearly 30.0, the "high" barometer over the Atlantic just bordering on the coast states. The low area is over the interior and southwestern parts of the country. Another "high" area exists off the northern Pacific states. Only twenty-seven auroral appearances were recorded, none of great brilliancy or extent.



In June the pressure distribution has been disturbed from that of the preceding month, well marked "lows" existing in northern New England and Saint Lawrence valley, and in the Rocky mountain regions. The "high" of May has moved southward and contracted somewhat. Fifty-nine auroral displays were reported, more than double the number reported for the preceding month. The auroral display of the 14th was visible from Mount Washington westward to Dayton, Wash. T. The

great increase in the number of thunder-storms (five hundred and ten) is also to be noted. The pressure conditions over certain regions being now exactly the reverse of those of November and December, when, as has been mentioned above, the minimum number of these disturbances were reported.

The curve of auroral frequency for the year, then, shows two maxima and minima, the former in April and September, the latter in August and January. The maxima occur at times when the pressure distribution is in a state of change, or when the permanent "high" of winter is giving place to the prevalent "low" of summer, while the minima occur at those times when, so to speak, the pressure areas are fixed and settled in their residence. And again, an inspection of these tables shows that the maximum number of auroras occur at the same time as a mean number of thunder-storms.

Further, the curves seem to show at other times a correspondence in their directions. This opens at once, the question of the relationship that exists between the aurora and thunder-storm, and suggests that both are but different manifestations of the same action, due to similar causes and varying in appearance because of the different conditions of the places of occurrence. We recognize as an important factor in the formation of a thunder-storm the presence of warm, moist, ascensional air currents in close proximity to cold descending currents. This is what happens when an area of high pressure crowds and pushes in on an area of low pressure. Dr. Meldrum pointed out that the periods of maximum and minimum frequency of thunder-storms at Mauritius were easily explainable on such grounds. These periods occur at times corresponding to the southward and return movements of the permanent "high" that in winter is over central Asia. The thunder-storms of Mauritius prevail from the end of October to the middle of May, or during the time of greatest rainfall, or, again, during the time when the ascending convectional currents are strongest and most heavily charged with vapor and compelled in turn to give it up. A "low" is the prevailing condition of pressure over the locality at this time, and the effect of the closer approach (which occurs at this time) of the great "high" is naturally a stimulated action of the ascensional warm moist currents in the "low." It is always at the time of this increased action that we find the maximum number of thunder storms occur. So, we have seen, a similar condition of things to exist in the United States, especially in the districts where thunder storms are most prevalent. When the permanent "high" of winter encroaches on the permanent "low" of summer, when the pressure distribution, so to speak, is in an unstable state, then the maximum number of thunder storms occur.

The following table gives the actual pressure conditions and the number of thunder storms occurring in the year 1881 :

Place.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Cheyenne, Wyo	29.850	29.859	29.885	29.936	29.989	29.844	29.959	29.988	30.008	30.164	30.229	30.308
	0	0	0	4	7	4	8	8	2	0	0	0
Denver, Colo	29.928	29.928	29.937	29.962	29.988	29.791	29.901	29.934	29.966	30.125	30.280	30.338
	0	0	0	2	3	4	4	2	0	0	0	0
Dodge City, Kans	29.870	29.789	29.645	29.617	29.572	29.780	29.922	29.933	29.925	30.101	30.227	30.274
	0	1	1	3	5	6	6	8	4	4	0	0
Dubuque, Iowa	30.174	30.126	29.915	30.003	29.965	29.891	29.997	30.000	29.923	30.081	30.094	30.154
	0	1	0	1	5	11	11	5	11	3	0	1
Leavenworth, Kans	30.179	30.100	29.934	29.967	29.881	29.872	30.010	29.969	29.935	30.082	30.169	30.201
	0	0	0	4	10	12	2	2	1	1	0	0
North Platte, Nebr	29.867	29.780	29.656	29.628	29.553	29.798	29.933	29.910	29.949	30.148	30.250	30.305
	0	0	0	2	4	11	4	2	3	1	0	0
Pioche, Nev	29.811	29.801	29.775	29.779	29.751	29.845	29.946	30.021	30.092	30.250	30.343	30.533
	0	0	0	3	0	0	6	0	0	1	0	0
Pike's Peak, Colo	29.649	29.716	29.753	29.943	30.050	30.184	30.299	30.256	30.074	29.979	29.788	29.839
	0	0	0	2	4	3	5	10	0	0	0	0
Tucson, Ariz	30.136	30.085	30.072	30.041	29.955	29.717	29.736	29.752	29.854	29.923	30.050	30.145
	0	0	0	0	0	0	1	1	2	2	0	0
Yankton, Dak	30.260	30.172	30.083	30.063	29.925	29.713	29.972	29.927	29.905	30.102	30.155	30.185
	0	0	0	2	8	7	6	2	4	3	0	0

Thunder-storms, it must be remembered, like all other individual atmospheric phenomena, are due to individual pressure movements, and a table like the above, dealing with generic movements, can not be expected to show the nicest points of correspondence. But that the greater number of thunder-storms occur at times corresponding to the great pressure area movements is clearly evident, and apparently so conclusive, that we may almost say, the frequency of electrical disturbances in the atmosphere is in accord with the range of the pressure variations.

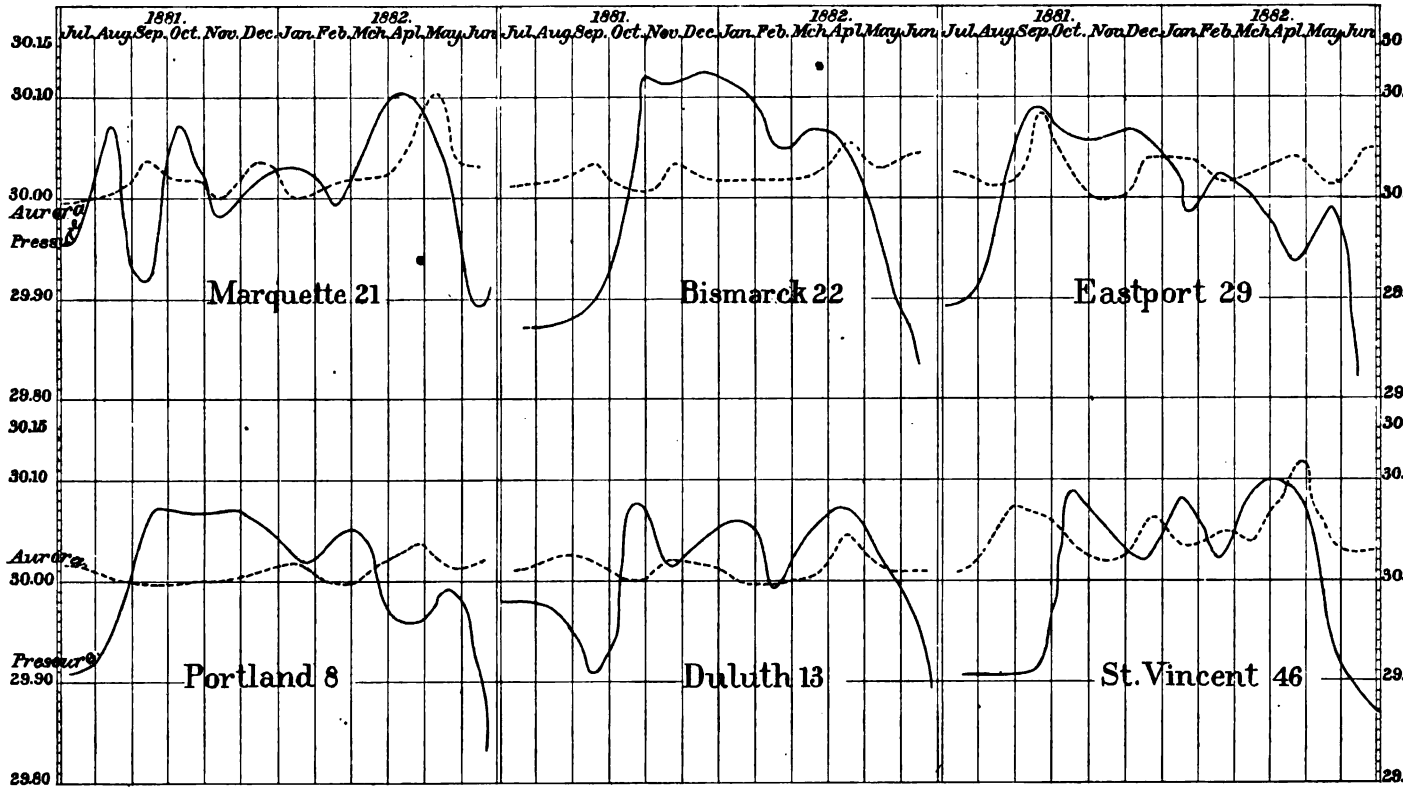
If we plot the curves of pressure variations and auroral frequency we shall, perhaps, more plainly see what relation exists between the two. For Marquette, Michigan, we find the pressure curve to be very irregular and the curve of auroral frequency similarly irregular. That is, Marquette is in a region where the pressure distribution is quite unstable, and in such localities we are to look for an increased number of auroral displays, other causes not preventing.

Similarly, if we compare Eastport and Portland we find that in the case of that locality, (Eastport) which has the more variable pressure conditions, there also is a greater number of auroral displays found to occur. If we study the curves given in the case of Saint Vincent, we shall see that during July and August the "low" area is there prevalent. By October the pressure distribution has been just reversed, and the "high" area then exists over this section of country. When the "high" began to move into this region, and when the influence of its close pressing in on the "low" is appreciable, then we find auroral displays to be quite frequent. When the "high" is fairly in the district, settled there, so to speak, we find a diminished frequency of auroral displays. As we shall see exemplified in individual auroral displays, further on, when a "low" area is being forced from its abode by a marked "high" area coming into the locality, then may we expect certain atmospheric developments, among the consequences of which we find the aurora and other electrical phenomena.

The following table shows the periodicity of auroral displays in places where their occurrence is frequent and the mean monthly pressure conditions for corresponding lines :

Place.	1881.						1882.					
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
Albany, N. Y	29.932	30.014	30.089	30.137	30.170	30.142	30.138	30.146	30.084	30.009	30.016	29.873
	0	0	2	0	0	0	0	0	1	2	0	0
Alpena, Mich	29.975	30.034	29.989	30.115	30.026	30.072	30.083	30.031	30.078	30.076	30.036	29.867
	0	0	6	2	1	3	1	2	1	8	3	2
Bismarck, Dak	29.886	9.850	29.922	30.139	30.137	30.144	30.132	30.065	30.083	30.052	29.924	29.837
	1	1	3	0	3	2	1	1	1	4	2	3
Burlington, Vt	29.887	20.977	30.055	30.103	30.100	30.088	30.056	30.101	30.050	29.977	29.987	29.828
	3	0	7	4	0	1	2	2	5	10	3	6
Detroit, Mich	29.985	30.044	30.030	30.136	30.125	30.149	30.154	30.082	30.091	30.059	29.992	29.876
	1	0	1	0	1	1	0	0	0	2	0	0
Duluth, Minn	29.971	29.966	29.880	30.077	30.014	30.059	30.084	29.997	30.070	30.107	30 025	29.900
	1	2	2	0	1	2	0	0	0	3	1	1
Eastport, Me	29.874	29.950	30.090	30.045	30.056	30.059	29.983	30.030	29.991	29.935	29.987	29.805
	2	1	6	3	0	3	3	2	2	3	1	3
Escanaba, Mich	29.961	29.999	29.917	30.075	29.952	30.052	30.082	30.007	30.069	30.086	30.017	29.865
	0	0	3	2	1	2	0	0	0	3	1	0
Ft. St. Michael's, Alaska	29.915	29.932	29.782	29.879	29.706	29.773	29.618	29.860	30 181	30.061	29.965	29.863
	0	0	1	3	4	4	2	6	2	3	0	0
Marquette, Mich	29.966	30.088	29.915	30.087	29.985	30.040	30.053	29.990	30.072	30.114	30.038	29.898
	0	0	3	2	0	3	0	1	1	6	3	2
Portland, Me	29.890	29.963	30.096	30.089	30.093	30.072	30.029	30.067	30.012	19.954	39.988	29.821
	1	0	0	0	0	1	1	0	1	3	1	0
Saint Vincent, Minn	29.914	29.907	29.890	30.109	0.066	30.033	30.103	30.033	20.105	30.111	29.968	29.874
	1	6	5	3	2	5	3	4	3	10	5	2

If, then, both thunder-storm and aurora are considered to be of similar origin, differing in appearance as one form of electric discharge differs from another, under dissimilar conditions of discharge, we have to ask ourselves, what are the



Relation between barometric pressure and auroral frequency.

atmospheric conditions determining the nature of the discharge? Is it mainly a question of height of the seat of discharge, and dependent on this, a question of the density of the di-electric, that distinguishes lightning from the aurora? If it is so, we could expect to find the height of the plane of auroral discharge variable, and also much nearer to the earth's surface than the distances generally given, since at the height of cirrus clouds the atmosphere is sufficiently rare to give up any electric charge it may have, at slight provocation. Then, too, since heat lightning would be the next form of discharge to that of aurora, perhaps some instances could be found showing a relationship between the two.

Professor Tyndall mentions seeing on Bel Alp vivid lightning displays, but without thunder and seemingly noiseless; hence, he termed them "silent lightning," though the inhabitants of that region call them "*wetter leuchten.*" Tyndall says, that whenever this occurred, a corresponding heavy thunder-storm always existed over the lower plains in Upper Italy. That a violent thunder-storm often terminates in heat lightning has been frequently noticed, and in several cases in an auroral display. Cases are fairly numerous where heavy thunder-storms had prevailed during an afternoon and evening, and then when the weather began to clear, true auroral lights (not reflections) were noticed. On July 5th, 1883, at Lewiston, Maine, a heavy shower with vivid lightning prevailed during the evening, and the weather clearing about midnight, there could be seen in the northern heavens a faint aurora, which increased in brilliancy. At Winnipeg, Manitoba, on July 30th, 1883, there was a heavy thunder-storm with much lightning in the afternoon, lasting until about midnight, when it seemingly resolved into an auroral display. It would be unfair to assume that mere coincidences will explain these occurrences, since in both cases the observers call attention to the impression made upon them while watching the storm's progress, that the auroral displays were the latter stages of the electrical disturbance which during the earlier part of the day was manifested as a thunder-storm. In a list of six hundred and eight auroras observed by Mr. F. G. Leuders, at Sauk City, Wisconsin, there are fifty-three occurring at times when heat lightning or thunder-storms within a very few hours had been noticed. In Boston, on July 29th, 1883, heat lightning was noticed during the early evening and followed later on by an aurora. Again, in this case, there can be little presumption of coincidence, because the observer watched the storm's progress and particularized his belief that the aurora was but a further development of the disturbance he was noticing.

Abbe, in a preliminary report of the aurora of April 7, 1874,* says that like several other auroras, to which attention was called in the Monthly Weather Reviews, this one was "associated with the prevalence of numerous thunder-storms south and west of the region experiencing the aurora, affording additional confirmation of the view, that both these forms of electrical manifestations are due to the same general cause." Von Bezold of Munich, in summing up the results of his researches on thunder-storm periodicity says that inasmuch as he finds thunder-storms to occur most frequently during periods when the solar surface is freer from spots than ordinarily, and on the other hand since the maximum frequency of auroral manifestations coincide with the maximum frequency of sun spots, then these two groups of electrical phenomena, thunder-storms, and aurora, complement each other as it were.† Sheet lightning, or any of the different types of electrical manifestations in the atmosphere, would then be regarded as intermediate types between the lightning and the aurora. Heat lightning is generally explained as an illumination due to distant thunder-storms. Not always, however, will this explanation hold, for certainly we often have "heat" and other forms of this diffused type of discharge, when we positively know that no thunder storm has occurred within sufficiently near distance

* Report of Chief Signal Officer for 1874, pp. 384, *et seq.*

† Nature, vol. xii., p. 127.

to allow of this illuminating effect. Professor Tait in a lecture on thunder-storms calls attention to the fact that heat lightning has been observed, when he was certain that no thunder-storm had occurred within a radius of one hundred miles. Loomis, many years ago, suggested that sheet and heat lightning in many cases were to be explained, not on the supposition of distant electrical disturbances, but of an actual discharge taking place in the air above us; the electrical discharge being feebler in intensity, and hence accounting for the absence of audible sound. There are many other points, interesting in this connection, and the following references all contain information, connecting with one another the various forms of electrical discharges in the atmosphere: Tait (Nature, vol. xxii., p. 438): Edlung (Petermanns Mittheilungen, 1879, p. 79); and Dellmann, Loomis, and Poey, in their meteorological observations.

If auroras are due to the same general causes as thunder-storms, and the occurrence more or less dependent upon atmospheric conditions, we must expect to find the seat of occurrence quite variable as regards its distance from the earth's surface; or in other words, the plane of auroral emanation must admit of quite an extended range with regard to its altitude. The determination of the height of the auroral plane has long been an attractive subject for discussion, though as yet without any very definite results. Most of the older investigations have placed it at a great distance from the earth's surface. Modern studies tend in the other direction, and depriving the aurora of any cosmical origin, place it at any and all distances from the earth's surface, a mean value being for localities of average frequency, not greatly in excess of the heights of cirrus clouds.

It is known, further, that with a change in latitude there is a change in the height of the auroral plane—a first proof of the fact that the plane of auroral occurrence is not fixed but variable. Adam Paulsen in results obtained from calculations of auroral heights in temperate zones (Godthaab) lying south of the so-called auroral belt, finds* that "they seem to be confined to that part of the atmosphere where its density is only a fraction of that at the sea surface; and however different this value may be for other regions, the average of the minimum heights (for temperate regions) is hardly under two hundred kilometers." We must notice, however, that such calculations are more or less erroneous, since it is not possible for two separate observers to fix on the same point in an auroral display, for both Weyprecht and Lemström bear testimony to the fact, that no two observers distant from each other see like appearances in an auroral display. As opposed to Paulsen's estimate, Abbe, having numerous observations of the great aurora of April 7th, 1874,† found that it was not possible to reconcile the reports on the assumption that the auroral light emanated from regions elevated a hundred miles or more above the earth surface; and the lower the seat of the phenomenon was placed, the better the agreement and the easier the reconciling of discrepancies. Assuming the average altitude of the arch to be sixty-nine miles, he was able to plot about fifty of the seventy-seven recorded arch formations, allowing liberally for errors of observation. Concluding his study of this aurora he adds, "considering not merely the apparent altitudes but the diverse appearances and motions of these arches, I am forced to conclude that these identifications are quite illusory; and the many records from New England and New York justify the conclusion that the auroral light emanated from a region much nearer the earth than sixty-nine miles, unless indeed, we give up the idea that the auroral light has a definite position."

Lemström and Tromholt, for high latitudes, agree in placing the auroral plane relatively close to the earth's surface; and the great mass of modern evidence favors the belief that auroras may occur at relatively low altitudes, and that the auroral plane is not excessively high, and has nothing like fixed limits, further than those

* Nature, February, 1884. † Report, Chief Signal Officer's for 1876, p. 307, *et seq.*

determined by the density and other conditions of the atmosphere. They have been seen at a less elevation than that of dense clouds, and also have been seen (and these are well authenticated cases) in close proximity to the ice surfaces in the Arctic regions. And not alone is the plane of discharge variable but the type of discharge also is modified by the atmospheric conditions. We have every type and variety of discharge that we could anticipate. Loomis distinguishes the various types and Weyprecht enumerates at least five different types, viz: Bogen (arch), Band (steamer), Füden (ray or beam), Krone (corona), and Dunst (or haze or diffuse auroral light). All these diverse appearances are exactly those given in laboratory experiments and as exemplified by the beams, streamers, merry dancers, arch formations, coronæ, and fringed curtains, differ only from the results obtained from electrical discharges through air of different conditions—by the greater scale and magnificence of their action.

In the records of auroras observed in this county for the past ten years, I find emphatic proof to support the statement that only when an area of "low" pressure is closely pressed by an area of marked "high" (in the United States, the "high" generally is on the southern or southwestern sides) is a display likely to occur. The maps showing annual auroral frequency show that in the great pressure area movements, the statement holds, while the maps given further on, of individual auroral displays, show much more in detail the relation between pressure movement and auroral occurrence. Like a thunder-storm, an aurora is an after effect of certain atmospheric operations, and as warm moist ascensional currents in close proximity to the cold dry descending ones are the conditions we find most frequently preceding electrical manifestations in the atmosphere, we infer that they are instrumental in starting those operations which have as a consequence electrical disturbances in the atmosphere.

We can easily trace a thunder-storm and note how it is an after effect of the movements of air masses, with the concomitant changes in humidity and temperature. It is quite possible to similarly trace the aurora and when we do so we find it progressing from west to east, following along on the outskirts of the "low" area varying in extent and brilliancy with advance of the "high." Forssman* has discussed at some length the relations existing between pressure conditions and auroral displays and magnetic disturbances; and finds that the records of Upsala, Saint Petersburg, Makerstown, Greenwich, Munich, Vienna, and Rome decidedly prove a certain modification of pressure to take place about the times of magnetic storms and auroral displays, at least over those localities in which the observations were made, and further, this modification was not accidental. The results of his researches are summed up as follows:†

1st. A certain barometric movement takes place during storms of great intensity and during auroral storms that extend beyond the zone proper of auroral occurrence.

2d. This change of pressure is of opposite nature in different parts of the European-Asiatic continent and probably also of the American continent.

3d. The dividing line (*i. e.*, where on one side the pressure change is an increasing one, while on the other side the pressure change is a diminishing one) crosses a little to the north of Scotland and runs southeasterly towards the Black Sea. During an aurora the barometer has an upward movement in the northeastern part, while it has a downward movement in the southwestern part of the continent. Mr. Sorel, in the Bull. International, April 21, 1870, says that "the relation which exists between auroral displays and great atmospheric movements is indisputable, although not yet very clearly defined;" and he further shows how, in both frequency and motion, auroral displays agree with the position and motion of great atmospheric areas. An

* "Des Relations de L'Aurore Boreale etc., avec les Phénomenes Meteorologiques."

† Pp. 54, et seq.

auroral display will journey from place to place with the progression of the conditions to which it owes its origin; and we might, therefore, test its obedience to the laws by which we explain its occurrence by predicting its appearance and intensity. We shall find, too, as in the case of thunder-storms, that certain localities are relatively free from auroral displays, while in others, in many respects similarly situated, auroras are frequent enough. The atmospheric conditions of a place, particularly with regard to density and amount of aqueous vapor present, will be found to affect materially the frequency of auroral displays. If the climate is dry and arid, there it will be found that a minimum auroral frequency occurs, while on the other hand a climate too moist gives also a minimum frequency, because in such conditions the atmosphere cannot accumulate an electrical charge, as the escape and dissipation may be as rapid as the accumulation. The best actual demonstration of this influence of atmospheric conditions on electrical manifestations is afforded, it seems to me, in the observations made at Fort Saint Michael's, Alaska. Here thunder-storms are unknown, not because they are rare in that locality, for a few miles inland, on the upper Yukon river, they are frequent enough in summer, but on account of the excessive humidity at the place of observation. That this absence is due essentially to the moist condition of the atmosphere is shown by the fact "that during the coldest weather of winter, and always after the occurrence of a snow fog, the air is in a highly electrified condition, and at such times a passing stroke upon any loose fur causes the hair to stand up, and so fully charged is it with electricity that presenting a finger to a single hair tip will often draw a spark. A rise in the temperature and the consequent increased amount of moisture in the air appear to effectually prevent any such manifestation, and a fall in temperature appears coincident with a highly electrified condition of the atmosphere."* Certain localities, it is well known, are remarkably free from electrical disturbances, and without doubt this absence is in a great measure determined by the atmospheric conditions of the place, particularly those of humidity and pressure. Along the sea coast, where the mean humidity is higher than inland, there is a less number of these electrical disturbances. At Block Island, R. I., we find only six thunder-storms occurred in the year, while at New Haven there were thirteen, the respective humidities being 77 and 71. At Pittsburg we find thirteen; at Toledo, twenty-five; at Chicago, twenty-six; at Davenport, thirty-one; at Omaha, forty; at Cheyenne, thirty-three; at Salt Lake City, twenty-two. At Delaware Breakwater there were only five, while at Washington there were nineteen; and similarly, at Barnegat, eight; at Philadelphia, thirteen. A very moist climate, then, is not favorable and on the other hand, in an arid climate, as our deserts, thunder-storms are also rare. Less marked would be the influence of local features upon the auroral frequency. A moist climate; proximity of water surface; regions of much cloudiness, (though this may obscure the aurora or lead to discharge of another type,) seem, however, to be characteristic of places having a maximum auroral frequency.

What, then, is the import of an auroral display to the meteorologist? We have considered it somewhat in the light of an after effect of certain atmospheric movement. The presence of an area of "high" pressure in close proximity to an area of "low" pressure we believe to be instrumental or at least an incentive to a more rapid accumulation of an electric charge in those localities experiencing the barometric fluctuation, or, in other words, on the border of "low" area nearest the "high." The steeper the barometric gradient, according to our assumption, the more brilliant and intense will be the aurora. Has the aurora any predictive value with regard to weather changes? It should have, and doubtless has. Payer says† that in certain latitudes in which the expedition was ice-bound, "brilliant auroras

*See Report of Chief Signal Officer for 1881, pp. 768 *et seq.*

†Austrian Arctic Expedition, 1882-4, p. 324.

were generally followed by bad weather, while, on the other hand, those which did not rise to any great height in the sky or show any special mobility were regarded as precursors of calms." Professor Christison is authority for the statement* that the first great aurora after autumn is well advanced (for Scotland) and following a period of fine weather, is a sign of a great storm of rain and wind on the forenoon of the second succeeding day. In the vicinity of Boston clear weather almost invariably follows an auroral display. Almost all arctic explorers have made suggestions concerning the value of the aurora as a weather prognostic. It has been a fertile source of speculation, especially among voyagers in the northern and southern seas, whether or not the color of an aurora was not in some way connected with coming changes in the weather. It has been suggested that the color was in some way functional of the change in pressure or humidity conditions, which undoubtedly occurs in the neighborhood of the auroral appearance. It is easy to conjecture that a barometric gradient of small value might give rise to the pale bluish or yellowish auroral light, while the deeper red colors and more brilliant streamers indicate a more marked difference between the two pressure areas. Captain Maclear, of the Challenger Expedition, suggests† just such a relation, and instances the fact that red auroras are comparatively rare in some localities, while other colors were frequent enough. So, in some parts of northern Europe, the usual color of an auroral display is pale yellow, red being markedly absent. In many cases in this country a steep barometric gradient is followed by the intense and brilliant display, while a less gradient is followed by the paler and less brilliant type.

There is one other interesting and instructive feature in connection with auroral displays and their meteorological bearing, and that is the question of cloud formation. As the seat of the auroral action is in similar regions, it is worth while to search for any bearing of the one on the other and to give at length the evidence that would tend to connect auroral action and cloud formation. So keen an observer as Clement Ley, despite the evidence of many others, fails‡ to find any relationship between the aurora and cirro-stratus clouds. In discussing the observations of Mr. Barber, confirming the existence of auroral clouds, Ley says that after many years study of the forms and directions of the cirro-stratus bands and fibres, he can make out no connection between them and auroral displays. The direction of the cirrus coincide but slightly with the magnetic meridian, frequently being transverse to it. "The direction of these bands is undoubtedly dependent upon or at least connected with the distribution of atmospheric pressure and currents. No relation has hitherto been pointed out between the condition of atmospheric currents and the auroral manifestations. The altitude of the aurora, though very variously determined and probably very variable, is certainly vastly greater than that of cirrus clouds, and therefore admitting (as I am not prepared to do) that the directions of the bands and fibres of cirrus are determined by conditions similar to those which determine the position of the arches and streamers, we shall still expect to find no distinct relation between the lines of cirrus and aurora, for most cloud observers will have noticed clouds differing from one another only by a thousand or two yards in altitude, arranged in bands which are far from parallel. On the other hand, I admit that some good authorities have believed in the existence of the relation which I cannot trace, especially Mr. W. Stevenson (Phil. Mag. for July, 1883)."

Cirrus clouds in general would not be expected to exhibit either in appearance or direction any evident connection with the arches and steamers of auroræ, but in special cases and at individual times only would a relationship exist. A specific type of cloud, the presence of this type at times of auroral displays and its seeming

* Proceedings Royal Society, Edinburgh, 1868.

† Auroras and their Spectra, p. 55, by J. R. Capron.

‡ Quarterly Journal, Meteorological Society, for 1878, p. 193 *et seq.*

dependence upon the auroral action, are the only points insisted on by the greater number of cloud observers. The direction of these cirrus bands, their axes and formations would appear different in different places, and though in their origin they may be dependent upon auroral action, and after formation, perhaps influenced by this auroral action, they are none the less at all times subject to general atmospheric laws. We must allow that electrical discharges of any extent in the atmosphere are competent to set in motion operations modifying the condition of the air relative to the amount of matter suspended therein. Small dust particles electrified have always a tendency to congregate into larger masses, and consequently to settle. The result of a deposit of dust and other particles is a changed condition of the air with regard to the matter floating in it, the one factor upon which cloud formation is particularly dependent. One very interesting example of this influenced cloud formation, in which, it seems to me, some other cause than those ordinarily engaged, was at work, and which seems to show the mingling of causes, is given by the following case of what might be termed auroral cloud formation:

On August 1st, 1884, the mean pressure was about 29.980. On August 2d the pressure increased rapidly and an area of "high," was in close proximity and advancing rapidly. At 9 a. m. the wind being from the west, the pressure high (30.202), the sky was covered with the peculiar cirro-stratus cloud always characteristic of an aurora in this place (Boston). An hour later the pressure having varied only .002 inch, the temperature the same, and the wind steadily from the west, the sky was half covered with these auroral clouds. From this time on throughout the day the barometer fell at a rate of about .006 per hour, the temperature hardly varied, and the wind was steadily from the west. The auroral clouds continued present until noon, when the sky being in every other part clear and slightly hazy, these clouds were resolved into an arch of cirro-stratus cloud, running from east to west, at right angles to the magnetic meridian, the altitude of the central part of the arch being about 60° and the width of the arch about 4°. This arch retained its shape very definitely throughout the afternoon, the form remaining, though the cloud matter moved steadily and at a fairly rapid rate to the east.

Glaisher has also given* an account of an interesting appearance which evidently was the result of auroral action on cloud matter On a certain date (the greatest display of 1870), his attention was called during the early part of the day to a peculiar appearance of the sky. The sky was covered over with clouds, except that an arch of clear space with its centre in the magnetic meridian existed in the north. The fixity of this arch and the marked avoidance by the clouds were noticeable, and, as the magnetic elements were greatly disturbed at the time, he considered it a clear case of auroral action on cloud matter. The absence of clouds in this arch of clear sky was the more remarkable, because in all other portions of the sky the clouds, owing to a strong northeast wind then prevailing, were driven rapidly across the sky. "The clouds immediately above the top of the arch seemed to be charged with electricity, their edges assuming the ragged appearance common to thunder-clouds, and at times were slightly tinged with a reddish color."

Every one who has attentively watched an auroral display must have noticed the presence of these small feathery cirrus clouds, sometimes floating slowly, sometimes remaining spread along the northern sky, as if fixed or held back by some invisible power. Almost always they resemble in form, direction, and location, the aurora itself. We have called them auroral clouds, a formation due to auroral action. To account for their presence, many different explanations have been advanced. The vapor of water in the air, it has been suggested, undergoes condensation during an auroral display. Far more probable is the hypothesis that the minute

* Nature, p. 259.

ice crystals which are present in the higher regions of the atmosphere, are with the dust and other particles, electrified during an auroral display, and then aggregating in larger masses, and settling, become visible to us as cirrus clouds. There can be little doubt that at times of auroral displays these characteristic clouds are present. In the charts given in this paper, it will be noticed that the cloud conditions during times of auroral displays confirm these statements. These charts show too, that for this locality after an auroral display, clear weather generally prevails and there is a marked agreement in regard to precipitation, wind, and weather. Haziness frequently is noticed at these times, and very often a slight or inappreciable rainfall. The maps and charts are mostly self explanatory. Maps I. to V. are designed to show the correspondence between auroral occurrence and a certain condition of pressure distribution. No particularly favorable data have been chosen.

Showing barometric variations

August 3d.

	11 a.m.	3 p.m.	7 p.m.	11 p.m.
30.2				
30.1				
30.0				
29.9				
29.8				
29.7				
29.6				
29.5				
Pressure	30.00	29.985	29.995	30.032
Temperature	80.5	78.0	70.0	67.0
Rel. Hum.	42.0	52.0	76.0	84.0
Wind	S.E.	S.E.	E.	0
	6.	4.	5	0
Weather	Clear	Clear	Fair	Clear
Clouds Upper	Cir:	Cir:	Cir:	—
	2	2	5	
	0	0	N.W.	
Clouds Lower	—	—	—	Lt. Haze
Rain	No rain until August 8th 16			

Description of aurora.—First noticed at 8 p. observed from Maine to Oregon and along the At southwestern of the places which record its appear At Boston began 8 p. m. At New York City, 7.50 p. disappearing at 9.15 and only a patch of light wi streamers and waves.

Remarks.—Was followed by dry weather. A northern New England, and an area of high to the clouds previous to the aurora were reported as wit both before and after.

Showing barometric variations + + + + + = du

August 9th.

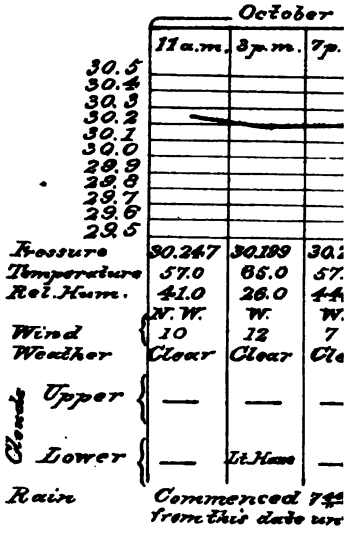
	11 a.m.	3 p.m.	7 p.m.	11 p.m.
30.2				
30.1				
30.0				
29.9				
29.8				
29.7				
29.6				
29.5				
Pressure.	29.691	29.695	29.759	29.822
Temperature	82.5	88.5	79.5	74.0
Rel. Hum.	62.0	44.0	66.0	71.0
Wind	S. W.	W.	S. W.	W.
	8	9	10	8
Weather	Cloudy	Fair	Fair	Clear
Clouds Upper	Cu. Cu.	—	—	—
	3 5			
	SW. NW.			
Clouds Lower		Cum.	Cu. Str.	
	—	7	4	—
		S.W. 2	W.	
Rain	Commenced 11 P.M. of 10th, ended 12 M.			
	until the 16th when quite a hea			

Description of aurora.—Of a pale green color, lasted a few hours. Seen also at Plattsburg, N. hours or so earlier. Auroras were suspected on th

Remarks.—An area of high pressure entered Missouri valley, and on the next day was in the C there until the 16th. On the 10th and 11th an a. the 9th to the 14th auroral displays were report displays were more or less faint and of short dura

22-2

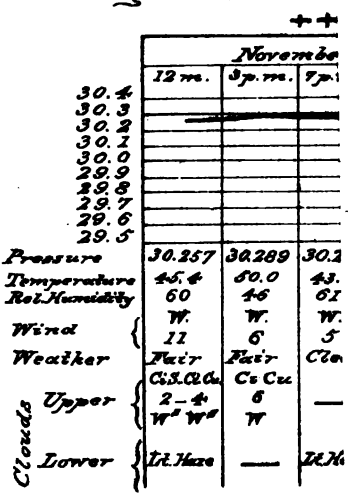
Showing barometric varia

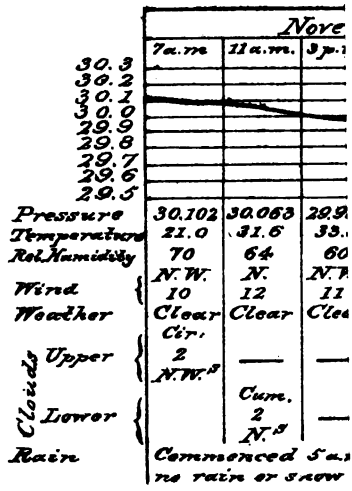


Description of aurora.—Fr
blue color, with waves and st
Washington, Eastport, and Por
changing to crimson after midn
arches, waves, streamers, and p
Remarks.—An area of hig

22-3

Showing barometric ra





Description of aurora.—Possi
beginning a little before daylight.
could not be sent. Late in the af
interrupted. A very short circuit
wires to Chicago could not be w
aurora alone the transmitting po
Albany ignited. Switch-board an
America and across the Atlantic a

Remarks.—On the 16th a "l
west, and northwest. On Novemb
states. About this time the treul
"high" over the Saint Lawrence
considerably interfered with obse
only upper-cloud observations ah

12 - 4

Showing barometric varia

	December		
	11 a.m.	3 p.m.	7p
30.2			
30.1			
30.0			
29.9			
29.8			
29.7			
29.6			
29.5			
Pressure	29.615	29.655	29.
Temperature	28.0	27.0	21.
Rel. Humidity	64	64	7(
Wind	W.	W.	W
	18	20	1
Weather	Fair	Clear	Cle
Clouds Upper	Cum.	Cum.	
	4	1	—
	W.S	W.S	
Clouds Lower			St
	——	——	2
			0
Rain	No rain or snow un		

Description of aurora.—A well-d
Observed throughout New England a
altitude of central part being 20°. I
Remarks.—The meteorological
make the time of display longer than

Showing barometric variati

	February		
	11 a.m.	3 p.m.	7 p.
30.8			
30.7			
30.6			
30.5			
30.4			
30.3			
30.2			
30.1			
30.0			
Pressure	30.078	30.127	30.3
Temperature	32.0	28.8	21.
Rel. Humidity	68	56	75
Wind	W	W	W
	12	17	16
Weather	Fair	Clear	Cle
Clouds Upper	Cum.		
	7	——	—
	0		
Clouds Lower		Cum.	
	——	3	—
		W.S	
Rain	Snow commenced 10 ℔ p.		

Description of aurora.—Began 7.2
generally noticed.
Remarks.—At the time of display
rounding it on the south and west. T
pare with chart No. 11.)

Showing barometric varia

April 3d.

	11 a.m.	3 p.m.	7 p.m.	
30.4				
30.3				
30.2				
30.1				
30.0				
Pressure	30.134	30.069	30.111	
Temperature	41.0	39.0	38.0	
Rel. Humidity	48	54	66	
Wind	E.	S.E.	S.E.	
	11	9	2	
Weather	Clear	Fair	Fair	
Clouds Upper		Ci. Str.	Ci. Str.	
	—	6	5	
		0	S.W.	
Clouds Lower	—	—	—	
Rain	Heavy frost on mora Began at 7 a.m. of 5th, am			

Description of aurora.—Noticed a
light rendered it invisible. Was gener
Atlantic states.

Remarks.—The pressure over new
"high," 30.3+.

Showing barometric vari

July 29th.

	11 a.m.	3 p.m.	7 p.m.	
30.1				
30.0				
29.9				
29.8				
29.7				
Pressure	29.799	29.765	29.840	
Temperature	77.0	79.0	73.0	
Rel. Humidity	60	58	50	
Wind	W.	W.	W.	
	6	17	11	
Weather	Fair	Clear	Clear	
Clouds Upper	—	—	—	
Clouds Lower	Cum.	Cum.	Cum.	
	5	2	1	
	W.²	S.W.⁵	0	
Rain	Showery on the 29th a at about 8 p.m. of the			

Description of aurora.—Began ab
was covered with patches of bright
yellowish light which seemed to be sep
stationary from 9.30 to 10 p.m. At m
At several different points it was noti
display. The aurora was generally se

Remarks.—Pressure distribution

Pressu
Temper
Rel.Hun
Wind
Weathe
Clouds Upp
Low
Rain

Da
Major, a
of Nove
Ba
this aar

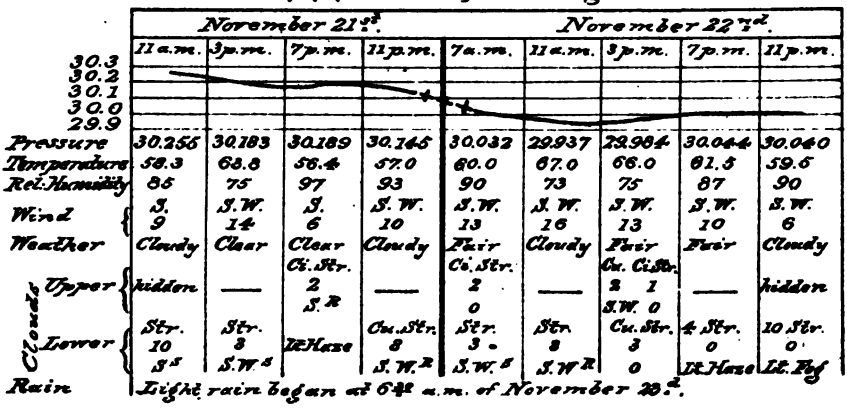
Pressu
Temper
Rel.Hun
Wind
Weathe
Clouds Upp
Low
Rain

Da
of the 19
were cas
denoted
Re

Chart № II.

Showing barometric variations accompanying magnetic storm of November 21st, and 22nd, 1883.

+++ = aurora prevailing


November 21st.
November 22nd.
11 a.m. 3 p.m. 7 p.m. 11 p.m. 7 a.m. 11 a.m. 3 p.m. 7 p.m. 11 p.m.
30.3
30.2
30.1
30.0
29.9
Pressure 30.255 30.183 30.189 30.145 30.032 29.937 29.984 30.044 30.040
Temperature 58.3 63.8 56.4 57.0 60.0 67.0 66.0 61.5 59.6
Rel. Humidity 85 75 97 93 90 73 75 87 90
Wind S. S.W. S. S.W. S.W. S.W. S.W. S.W. S.W.
9 14 6 10 13 16 13 10 6
Weather Cloudy Clear Clear Cloudy Fair Cloudy Fair Fair Cloudy
Cl. Str.
Clouds Upper hidden — 2 — 2 — 2 1 — hidden
S.E 0 S.W. 0
Lower Str. 10 S Str. 3 S.W.S Cu. Str. 8 S.W.E Str. 3 S.W.S Str. 8 S.W.E Cu. Str. 3 0 4 Str. 0 10 Str. 0
Haze Lt. Haze Lt. Fog
Rain Light rain began at 6.42 a.m. of November 23d.

Description of aurora.—Became visible at 1.30 a. m. of November 22d. A straight, thin beam shot up from magnetic north, reaching almost to the Pleiades. At 2 o'clock luminous pale blue cloud patches appeared on both sides of the beam. At 2.30 many streamers, and the heavens half covered. At 2.45 deep red beam in the northeast. At 3 o'clock this had faded away, but a few minutes later became more brilliant than before. The whole display then seemed to settle and partially assumed an arch form. At 3.50 a. m. had changed into a curtain with fringes, much more like an aurora of Arctic regions than of temperate climes. From 4 o'clock it gradually became paler. This aurora was one of the very brilliant and varying type, and a marked change in the weather was presaged.

Remarks.—On November 22d a very well defined low (29.50) extended over the regions to the north and northwest of Boston and around Lake Ontario and thence northward, inclining to the northeast. To the east, all over Nova Scotia, an area of high extended. Altogether there were two areas of high pressure with a low in the centre. The seat of disturbance in this aurora was thought to have been more to the northwest than is usual. (Compare with chart No. 6.)

Form 106 F.

Years 1881 and 1882.

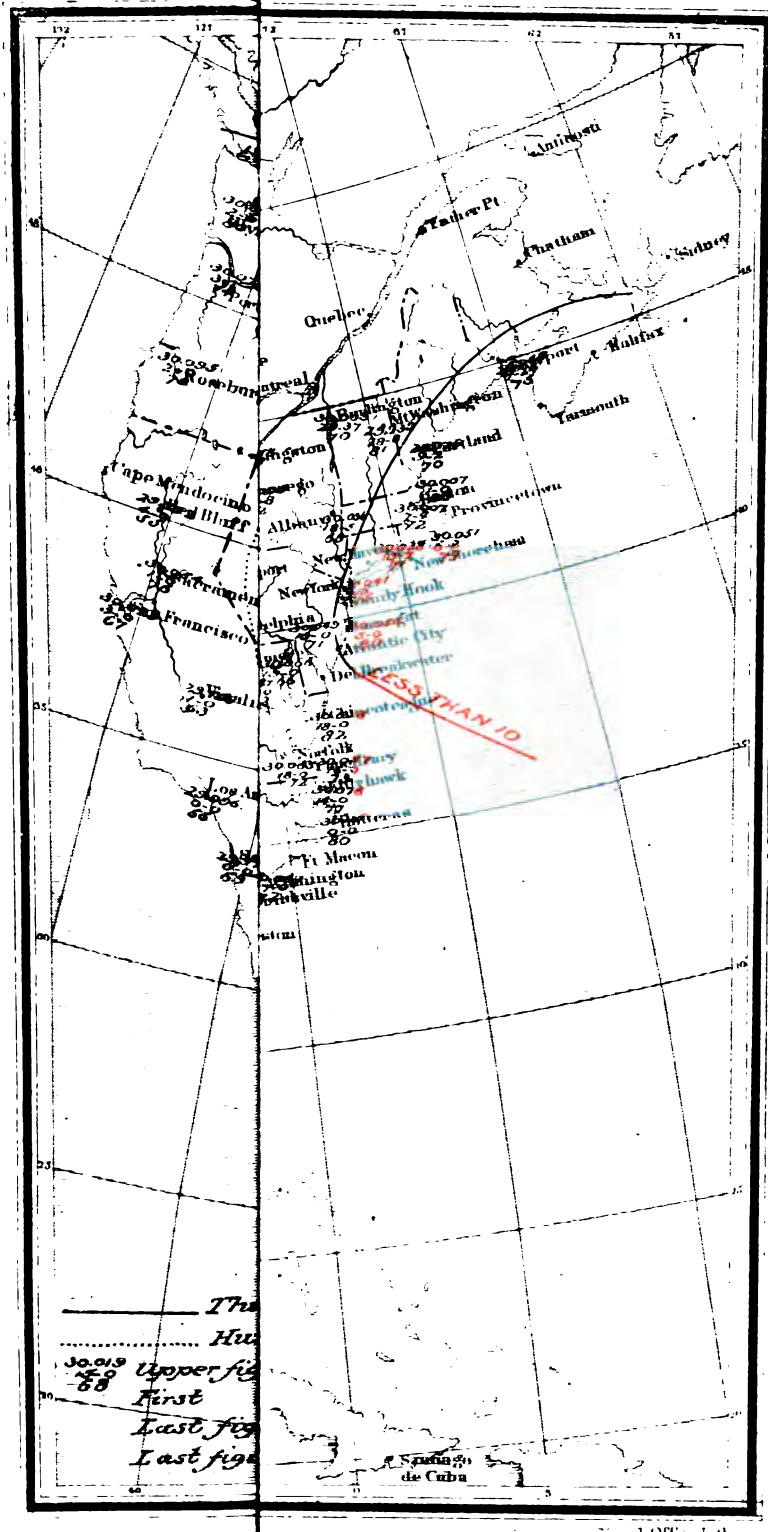
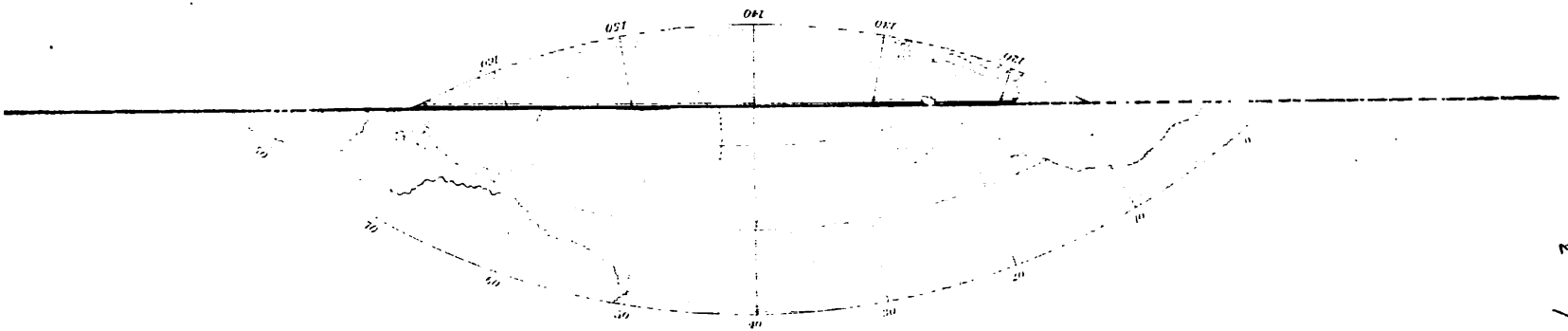


Chart showing Isochasmen or Lines of Equal Auroral Frequency.

[From Petermann's Mittheilungen, 20 Band, 1874—IX.]

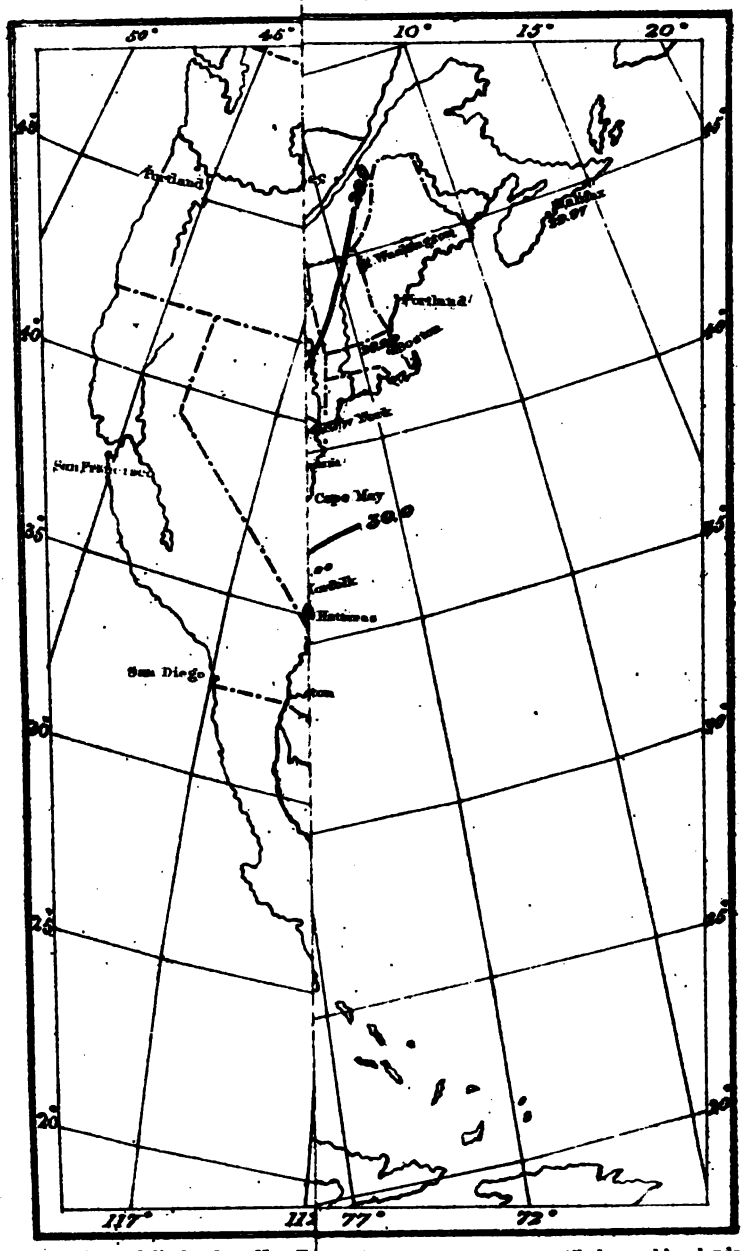


UNITED STATES OF AMERICA.

By Order of the Secretary of War.
W.B.Hazen, Chief Signal Officer.
Signal Office Lith.

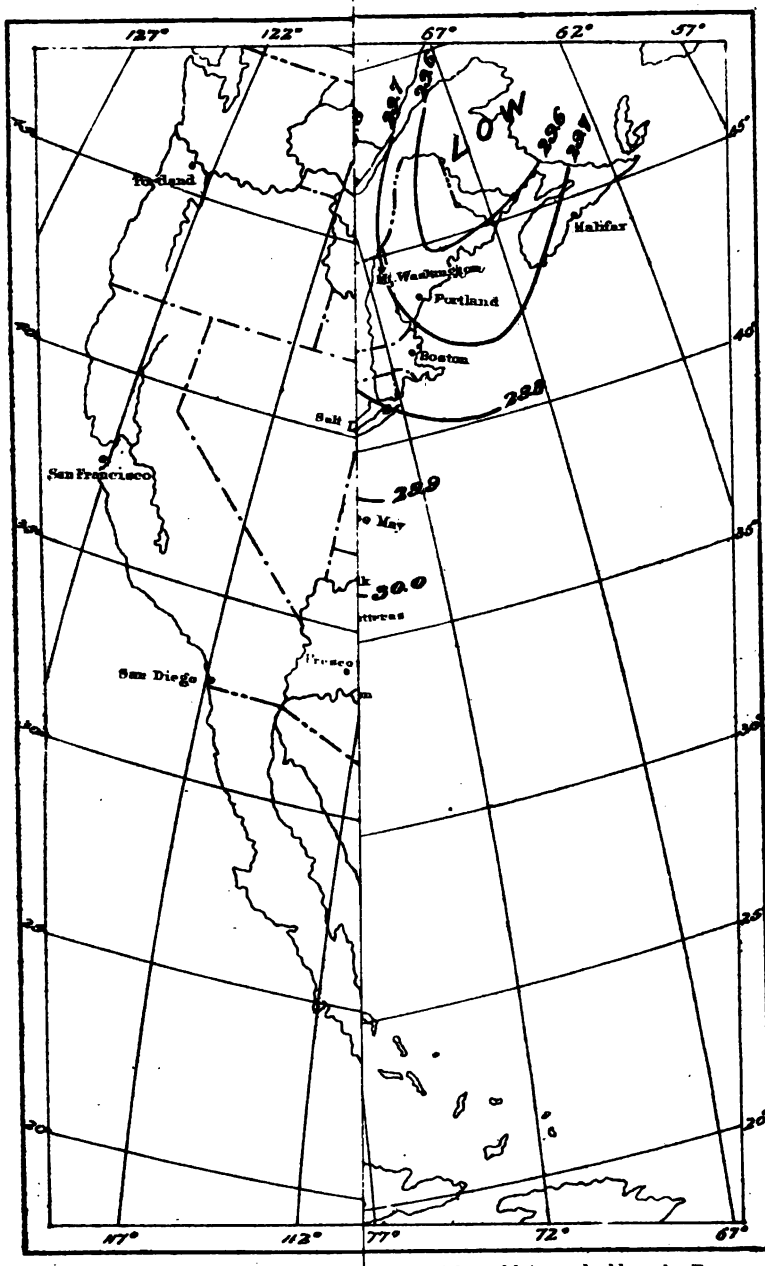
———=Isochasmen.
----------=Magnetic meridians.

83, 11 p. m.



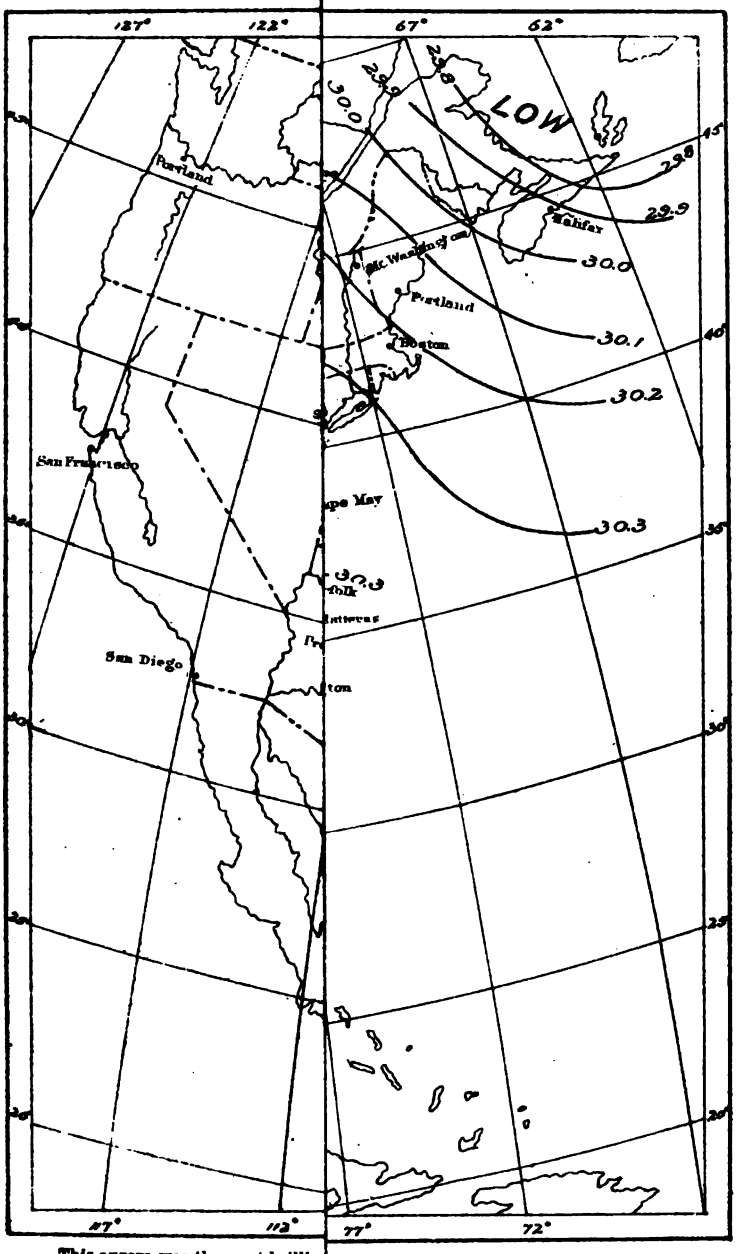
Auroral display from New Ipson, N. H., from 10.15 p. m. until obscured by clouds at 11.40 p. m.; Marquette, Mich., fr

Map showing barometric faint intensity, and also visible

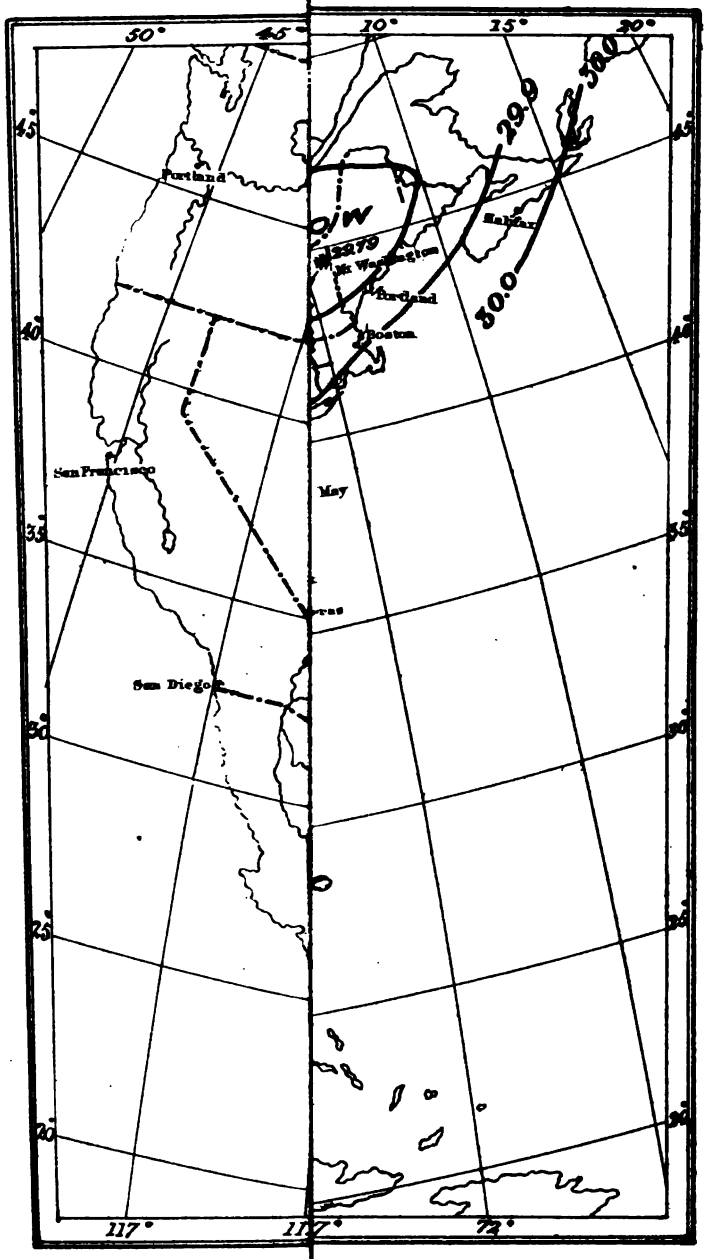


Auroras were seen at Duluth, Minn., green light and later as double arch; Eastport, Me., 7.30 p. m. to midnight. Display als

7 a. m.



This aurora was the most brilliant ... aunton, and Cambridge, Mass.; Eastport, Cornish, and Gardiner, Me.; Newport, Vt., Ithaca



At Charleston, S. C., an aur a bright radiance on the sides of the buildings. Note that little to north of Charle rly the one at Smithville, while all to the south and southwest are high.

UNITED STATES OF AMERICA:
WAR DEPARTMENT.

SIGNAL SERVICE NOTES NO. XIX.

REPORT

HARVARD COLLEGE LIBRARY

ON THE

TORNADO OF AUGUST 28, 1884,

NEAR

HURON, DAKOTA.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY,

BY

SAM. W. GLENN,
SERGEANT, SIGNAL CORPS, U. S. ARMY.

BY AUTHORITY OF THE SECRETARY OF WAR.

WASHINGTON CITY:
SIGNAL OFFICE.
1885.

UNITED STATES OF AMERICA:
WAR DEPARTMENT.

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WASHINGTON CITY:
SIGNAL OFFICE.
1885.

1885. May 28,
Gift of
The Signal Office.

NOTE.

The publication of this Signal Service Note is made for the purpose of bringing it to the attention of the public. The Chief Signal Officer does not thereby necessarily endorse the views set forth.

REPORT ON TORNADO NEAR HURON, DAKOTA.

HURON, DAKOTA, *November* 1, 1884.

To the CHIEF SIGNAL OFFICER, U. S. Army, Washington, D. C.

SIR: I have the honor to submit the following report on the tornado in this vicinity, August 28, 1884:

Accompanying are one chart, five figures, and five crayon sketches. Chart I. exhibits the meteorological conditions at this station on August 27th, 28th, and 29th.

Fig. 1 exhibits the character and position of the clouds previous to the formation of the tornado.

Fig. 2 exhibits the character and position of the clouds after the tornado had passed, and six funnels were visible.

Fig. 3 exhibits the circulation of the atmosphere about the tornado.

Fig. 4 exhibits a possible area of atmospheric conditions especially conducive to the formation of tornadoes.

Fig. 5 exhibits the several pressures which appear to have attended the tornado.

Sketch 1 represents the tornado when the cloud and ground disturbances first connected.

Sketch 2 represents the tornado when crossing the Dakota river, at a point three-fourths of a mile from the centre of Huron.

Sketch 3 represents the tornado when destroying Mr. John Cook's residence, about three miles southeast of Huron.

Sketch 4 represents the tornado in the act of contracting and bounding from point to point.

Sketch 5 represents the clouds when six funnels were visible, about fifteen miles distant.

August 27th was a warm day, but the heat was not especially oppressive; the weather was generally fair, with slowly falling barometer and fresh southeast wind; cirro-stratus clouds predominating. As the sun neared the western horizon, the sky assumed a smoky-red appearance, which extended in broad glaring rays half way to the zenith after the sun had disappeared. Heat-vapor could be observed extending from fifteen to twenty degrees above the horizon. The night was clear, but warm and close, the prevailing southeast breeze seeming laden with a sultry moisture. At 9.36 p. m. the standard thermometer registered 71°.5, and fell only 1°.5 during the night, something unusual at this station.

August 28th opened with a dense fog, which had begun sometime in the night, continuing until eight o'clock a. m. The air was extremely sultry although a fresh breeze was blowing from the south. The fog was succeeded by heavy stratus clouds, which suddenly dispersed at ten o'clock a. m., revealing a glaring white atmosphere through which the rays of the sun fell with scorching power. Detached groups of murky cumulus clouds formed in the south, drifted slowly northward and disappeared. The barometer fell slowly, while the temperature steadily increased. The atmosphere seemed heated to a much greater degree than the temperature registered by the thermometer would warrant. There seemed to be a lack of something necessary to easy and natural respiration. These conditions continued all the forenoon. About 1.45 p. m. a heavy bank of white cumulus clouds, probably the accumulation of the detached groups which had been drifting from southward, formed

in the north, gradually subsiding into a milky-blue stratus cloud, which extended along the horizon from north to northeast, faced by perpendicular streaks of a darker color. The whole had much the appearance of the primary formation of a mid-summer thunder shower. The drifting cumulus clouds from the several directions seemed to concentrate at a point a little west of north (see Fig. 1), where they would become considerably agitated, and finally form a part of the main bank of clouds. The observer cannot better illustrate the peculiar movements of these clouds when nearing the common centre "X" (Fig. 1) than by comparing them to the confused and uncertain whirling of a flock of sea gulls just before a storm. Soon a narrow stratus cloud formed along the southern horizon, extending a little west of south, and apparently connecting with the cloud in the northeast at a point a little south of east (Fig. 1).

About 2.30 p. m. the air was so sultry that the most ordinary exercise would cause the perspiration to start from every pore. Numerous inquiries were made at this office relative to the temperature, the general impression being that it was over 100° in the shade, when, in fact, the register showed only 86°. The sultry conditions continued until 3 p. m., when from the western edge of the rapidly increasing mass of white cumulus clouds in the north there appeared a white funnel-shaped formation, whose point would extend and contract toward and from the earth, but having no apparent connection with it. In a few moments, however, a cloud of dust resembling the smoke from a newly-fed locomotive was seen to accumulate on the ground, acquire a rotary motion, and form in the shape of an inverted letter "V." With the swiftness of thought the funnel-shaped cloud dropped a considerable distance down, and spun out toward the ground a white, ribbon-like line, around which there was a rapid rotary motion from left to right. The cloud and ground disturbances were immediately connected by a smoky-looking flue or column which also had the rotary motion and whose centre had the semi-transparent appearance of steam near the orifice of an "escape valve" (sketch 1). At this time the ground disturbance was at least three hundred feet in advance of the cloud disturbance, and at times during the tornado was from two to three hundred yards in advance. A number of times when the tornado appeared to be at its maximum power, and especially when an object of any kind was encountered, it seemed to recruit its force from the clouds by a white line or thread with a round bright mass at its end, which would dart down with remarkable rapidity, and after the obstacle was removed, slowly contract, until out of sight. Through the field-glasses the observer could easily distinguish that it had the appearance of opaque glass, a little darker than the ever present white line, hence he was led to believe that it was a current of electricity, around which just sufficient moisture was condensed to make its outline visible. It had a spiral motion which could be easily distinguished. The simplest way to illustrate its appearance would be to compare it to an ordinary penny stick of lemon candy, striped with white and blue. To persons unaided by glasses, only the round bright mass at the end of the white line was visible, which has been described by many as a ball of fire. There is no evidence to show that ignition occurred, but in the course of investigation the observer found blades of corn which appeared to have been scalded, or gone through some process which instantly and completely destroyed all sap and fibre, leaving the integument complete.

A farmer, whose grain stocks were destroyed, states that the straw immediately in the centre of the tornado's track was afterward found to be very brittle, as though dried by a high degree of heat. In another instance newspapers of recent date, found about two hours after the tornado had passed, easily crumbled in the hand, as though charred, although they were not discolored. This would indicate that the temperature of the air immediately around the column must at times have been very high, although not sufficient to cause ignition.

For several minutes after the tornado formed it appeared to remain stationary, then an oscillatory motion was observed. Suddenly the ribbon-like point extended nearly to the earth, a hissing sound was heard, and the column moved rapidly south as though coming directly through the town. When about three miles away a wavering motion was observed near the middle of the column, the line of progress changed from south to southeast, the width of the ground disturbance increased, and both the force and rate of motion of the tornado augmented. The white ribbon-like line now extended from the clouds to the earth. The funnel-shaped cloud was almost white, and continued so throughout so long as visible. The observer attributes this to the fact that the sun was shining at this point all the time the tornado was visible, while between the black tornado (sketch 5) and the sun a heavy mass of cumulo-stratus clouds remained almost stationary, or had a motion southeastward just equal to the rate of progress of the main storm cloud. The white tornado, as shown in all the sketches, was the one which passed near this city, while the black one (sketch 5) formed southwest of here, as will be explained further on. The nearest approach of the tornado to Huron was three-fourths of a mile northeast of the centre of the town, where it completely destroyed a stock barn belonging to Mr. A. H. Risdon. The east side of the structure was literally reduced to splinters, while the west portion, built partly in a niche cut in the bluff, collapsed, the whole side, however, remaining intact (sketch 2). It next struck the Dakota river (sketch 2), taking the water up so suddenly and with such force, as to leave the bottom for an instant exposed. The water was carried to a great height in a volume, and with the exception of the spray as shown in sketch 2, was not known to descend. The clouds around the funnel increased in size, and assumed a more threatening aspect immediately after crossing the river, which would lead to the belief that the water was converted into cloud.

The next obstacle encountered was an unfinished dwelling belonging to Mr. John D. Bloodgood, which was completely destroyed, some portions of it being carried four or five hundred feet into the air. Where the tornado crossed the Chicago & Northwestern railway no damage was done except that the telegraph wires were torn from the poles, but not broken. When at this point a broad streak of zigzag lightning passed parallel to the horizon across the cloud in the northeast, followed by a terrific peal of thunder, which shook the earth and reverberated for nearly two minutes, apparently along the line of the tornado's track. This was remarkable, from the fact, that, with the exception of an occasional hail stone of great size, no precipitation attended the tornado. Heavy rain, with some hail, occurred within twelve to fifteen miles of and parallel to the east side of the tornado track after it had passed a considerable distance southeast of here.

The dwelling of Mr. John Cook, about three miles southeast of town, was next struck (sketch 3) and demolished. Mrs. Cook and a daughter seven years old were in the house. They were both carried high in the air, receiving very serious injuries from which Mrs. Cook has not yet recovered. Soon after the black funnel (sketch 5) formed in the southwest while three smaller ones appeared at intermediate distances, also a small one on the west of the black one (sketch 5). The play of the black funnel on the ground was coincident with the contraction of the white one, and *vice versa* (sketch 4). As near as could be determined they were from twenty to twenty-five miles apart. The intermediate funnels depended only a short distance from the cloud, and at no time, while under observation from this point, extended to the ground (sketch 5).

The tornado moved southeast at an estimated velocity of forty miles per hour, and when not bounding (sketch 4) destroyed everything in its path, which was from eighty to one hundred and twenty-five yards in width. When bounding its point would pass within from twenty to thirty feet of the tops of objects without injury to them.

When last seen from this point the white tornado was rapidly contracting into the clouds while the black one appeared to increase in size and force.

The rate of increase or decrease of rotary motion of either was coincident with the increase or decrease of the motion forward.

Six lives were lost and much valuable property destroyed by the black tornado. No lives were lost by the white one so far as heard from, but considerable property was destroyed.

Numerous instances could be cited to illustrate the existence of an almost if not perfect vacuum in or immediately near the centre of the tornado, and a clearly defined line of demarcation between its destructive and non-destructive power.

About twelve miles southeast a section of virgin sod fourteen feet square and sixteen inches thick, was torn up, carried high in the air, and converted into dust. A gentleman living in the vicinity says he found evidences of a "gopher house" in the bottom of the excavation, which would indicate that confined air in the "gopher house" had expanded with such power as to force the crust of earth upward.

A Mrs. Briggs, living about fifteen miles south of here, who saw the storm coming, went into the cellar, an excavation about ten feet square and five feet deep, and crouched in an ordinary wash tub near the north wall. In the south side there was about six hundred pounds of butter; the house was lifted in the air, whirled rapidly round and demolished; the butter was lifted out of the cellar and scattered in every direction, while there was not sufficient disturbance where the lady was to indicate the presence of a gale outside. At this place a number of cattle and horses were taken from a herd, lifted bodily high in the air, and churned together in a living mass; thirty steers and four horses were instantly killed, and a number wounded. A remarkable thing in connection with this was, that most of the beasts appeared to have their lower jaws dislocated. The herder states that the uneasiness usually manifested by cattle just before a storm was not noticed in this instance.

About ten miles southeast a barn belonging to Mr. Kinney was destroyed; in it were two large horses with their harness on; the centre of the white tornado passed on the east side of the barn, which collapsed and was drawn into the tornado. The horse on the east side was taken up from thirty to forty feet, carried one-half mile, and laid down unharmed; the other horse was left standing within a few feet of its original position, hitched to a timber which had formed part of the structure; the harness, with the exception of the collars and bridles, was torn completely from both animals. Is it not possible that the position of the horse which was taken would correspond to "c," and the one not taken to "e" or "e d," Fig. 5? Near Alexandria, Dakota, Mr. Walter Peck was cutting hay with a two horse mower; his attention was attracted to the storm by the falling of scattered hail stones of remarkable size; he unhitched the team which became unmanagable, and broke away when the tornado was within about two hundred yards. Mr. Peck says he felt himself growing light, and seemed unable to keep his feet on the ground; by a great effort he sprang or plunged toward the west, falling prone upon the ground, his hands twined in the long grass; there appeared to be an immense weight on his body from neck to waist which held him close to the earth, his legs threshing the ground like two flails, and a tremendous force against the top of his head seemed pushing him toward the storm. The team fled in a direction at right angles to the storm's path and escaped injury; the mower was completely destroyed, although constructed principally of iron.

Is it not possible that Mr. Peck's position would correspond to "e" or "e c" in Fig. 5?

The following incidents are worthy of note: A piece of two by four inch lumber was found, to which an ordinary seven-eighths board had been fastened with spikes; the board was without scratch or flaw, with the spikes securely held where they had

been driven through it, while the timber was some distance away. The most expert carpenter could not have separated the two, without, to some extent, defacing one or the other.

Wherever wood work was glued together, even to the most frail ornaments, such as usually decorate modern furniture, the different parts separated without fracture and remained intact. Either the adhesive power of the glue was neutralized by some unknown element, or the different parts were torn loose by the expansion of the air necessarily confined in the process of glueing.

Long rows of shingles were found in the same order, and with the same "lap" as when on the building, the nails in their proper places, points up, and the timbers to which they had been attached nowhere in view.

At the Cook house (sketch 3) the wheels were torn from one side of a heavy wagon, leaving the other side perfect; the spokes were removed from a buggy wheel without break or scratch, leaving the hub and felloes as perfect as when new, natural wear and tear excepted.

The barn only one hundred feet from the house, which was demolished, was unharmed, except that the supports to which the sills were fastened, set deep in the ground, were found to have moved about one inch toward the tornado, showing that there must have been a great horizontal pressure very near the ground, as the barn remained perfectly plumb, combined with a strong vertical pressure which held the structure in its upright position. The roof was composed of heavy cross timbers covered with ordinary inch boards, which showed evidence of having been sprung down by some great pressure; a strong fact in support of the theory of two currents. In this instance the barn and wagon were in a position corresponding to "e," Fig. 5, while the house was at "c."

A small building at "e d," on the side of the barn farthest from the tornado, collapsed, the four sides remaining separately intact. From this it might be reasoned that the gravity of objects at "b," Fig. 5, would be overcome and they be torn to pieces by the centrifugal force arising from the rapid rotary motion from left to right; at "c" be taken into the tornado by the force of suction; at "d" would, if possessed of sufficient vertical strength, remain stationary, if not, would collapse.

The foregoing serve to show that there was in, or immediately near the centre of the tornado, a nearly, if not complete vacuum, and the destructive force was not from the elementary principle of the phenomenon, but from the pressure of the atmosphere in its effort to establish an equilibrium. Were the phenomenon the result of the presence of an accumulation of hot air alone, with a temperature much higher than that of the surrounding atmosphere, the great force of the wind on all sides would probably either have reduced its temperature to the common degree, or deflected it from its almost direct line of progress.

The following facts lead the observer to believe that the primary principle or governing factor of the tornado was electricity: The barometer did not indicate the presence of any decided storm-centre in this immediate vicinity, although the high wind of August 29th was strong evidence that one of considerable energy had existed farther east on the 28th. The velocity of the wind at this station on the 28th did not indicate that a "low" existed in the immediate vicinity. The funnels moved on the outer edge of white cumulus clouds of no threatening aspect, following in the rear of what appeared to be either stratus or nimbus clouds. No precipitation except the hail before referred to occurred anywhere in the vicinity of the tornado. The ground disturbance preceded the cloud disturbance at the beginning of the tornado, and every time it returned to the earth after having contracted. When the black funnel would descend to the ground, the white one would contract, and *vice versa*, showing a direct and intimate connection between the two somewhere in the upper atmosphere, either in or above the clouds. When in the act of

forming, the funnel connected with the earth by gradual waving undulations or extensions and contractions, each extension being greater in proportion than the preceding one, until the cloud and ground disturbances were connected (sketch 1). The clearly defined line of demarcation between the destructive and non-destructive diameters of the tornado's influence. The perfect and constant vacuum which appeared to exist in, or immediately around the centre of the column. The ever present ribbon-like white line, and especially the thread passing back and forth with the bright ball or mass at its end, rendered luminous perhaps by friction.

For several days preceding August 28th there existed many of the essential conditions to produce a superabundance of atmospheric electricity; dry air, dry wind, high temperature, and consequent excessive evaporation of moisture from the earth, and extended daily ranges of temperature.

Perhaps all these conditions, while tending each in its self to produce electricity, opposed a greater or less degree of resistance to its flow from the upper regions to the earth; hence the volume of static electricity in the upper atmosphere was probably very great, although so insulated by the absence of sufficient moisture to form a conductor as to have no active intensity.

Supposing such to have been the case, bearing in mind the preference of atmospheric electricity to a short imperfect over a long perfect conductor, and its tendency in spirals to a point, imagine the line a' a', Fig. 4, to be an area of warm moist air, or the western edge of clouds forming near a "low," at or farther east than "d," and the line a a to be the eastern edge of a volume of cold dry air coming from a "high" west or northwest of "e." A rapid condensation of vapor would occur in the intermediate area. The volume of cold dry air from the northwest would contain a great amount of static electricity, with a tension increasing in proportion to the increasing density of the atmosphere; the accumulating electricity would find in the condensing vapor a conductor which would convey it in its passage to the earth, at least as far as the base of the clouds, which are generally very low when tornadoes occur. In the case under consideration their estimated altitude was from four to six hundred feet.

With a knowledge of the affinity of opposite electricities, and an approximate conception of their great tension, it is easy to conceive that the distance between the clouds and the earth could be overcome, and an interchange be established between the two. The tornado's progressive track would then probably depend upon the direction from which the greatest pressure came, and the width of its path upon the size and force of the current, and the degree of heat generated by it in its passage through the air.

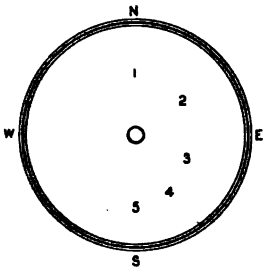
If the heat which appears from foregoing incidents to have existed was great the vacuum around the centre of the column could easily be accounted for. This tornado was attended by none of the premonitory characteristics which are generally supposed to accompany these phenomena, such as the "blue-black cloud rising in the west; the low muttering of thunder in the distance; the noise resembling many heavily laden cars crossing a bridge; the twilight darkness; the torrents of rain, with hail and incessant flashes of lightning and peals of thunder," etc. None of these preceded, accompanied, or followed it. The only indication that something unusual was about to occur was the peculiarly sultry condition of the atmosphere.

Imagine a vast treeless plain, void of hill or dale, and a sky unobscured save by small drifting cumulus clouds and a narrow band of light stratus cloud resting on the horizon in the northeast and south. Suddenly a commotion is observed in the cumulus clouds, which have piled up in a wooly mass in the north as though checked by some invisible barrier, separating them from the horizon and line of stratus cloud by a strip of clear sky. Then there is a rapid and confused whirling, the centre of the mass drops down bowl shaped and appears as though making futile efforts to

touch the earth. Extension follows extension until the end of the funnel connects with a cloud of dust rising from the ground to meet it. The connection between the earth and cloud being established it remains stationary a moment, apparently gathering strength before starting on its career of destruction. Then it moves rapidly over the plain destroying everything in its path. The manner in which objects moved toward the end of the funnel can be illustrated on a small scale by rubbing a piece of hard rubber on the coat sleeve until charged with electricity, then passing it slowly over dust or coal ashes spread on a piece of paper or glass.

It is greatly to be regretted that some of the prominent scientists of the age were not in the vicinity to witness the phenomenon under such very unusual circumstances and favorable conditions for intelligent observation. Perhaps some theories would have been strengthened and others weakened.

Perhaps the southern tornado early in the summer, represented as having such a destructive track, was the result of a number of funnels or columns, as shown in sketch 5, all being connected with the earth at the same time.



The accompanying sketches are enlarged copies of those made by the observer while the tornado was plainly in view (about one hour and a quarter) and are true representations of the phenomenon, as will be seen by the accompanying certificate of some of the most prominent men in the town and county. The accompanying figure shows the relative position of the observer when making them, "O" representing him, and the numerals the position of the tornado as to direction but not distance, as represented by the different sketches, 5 representing the position of the black funnel in sketch 5.

It is possible that the tornado in this vicinity was a continuation of the storm which passed over Winnipeg the evening of August 27th, and with increased force reached Evansville, Indiana, and Henderson, Kentucky, on the 29th.

Volunteer reports, probably now on file in the Office of the Chief Signal Officer, will better trace the tornado after leaving this county than the observer here could.

Hoping that this report may be of some service in the study of tornadoes,

I am, very respectfully, your obedient servant,

SAM. W. GLENN,
Sergeant, Signal Corps, U. S. A.

HURON, DAKOTA, *October* 27, 1884.

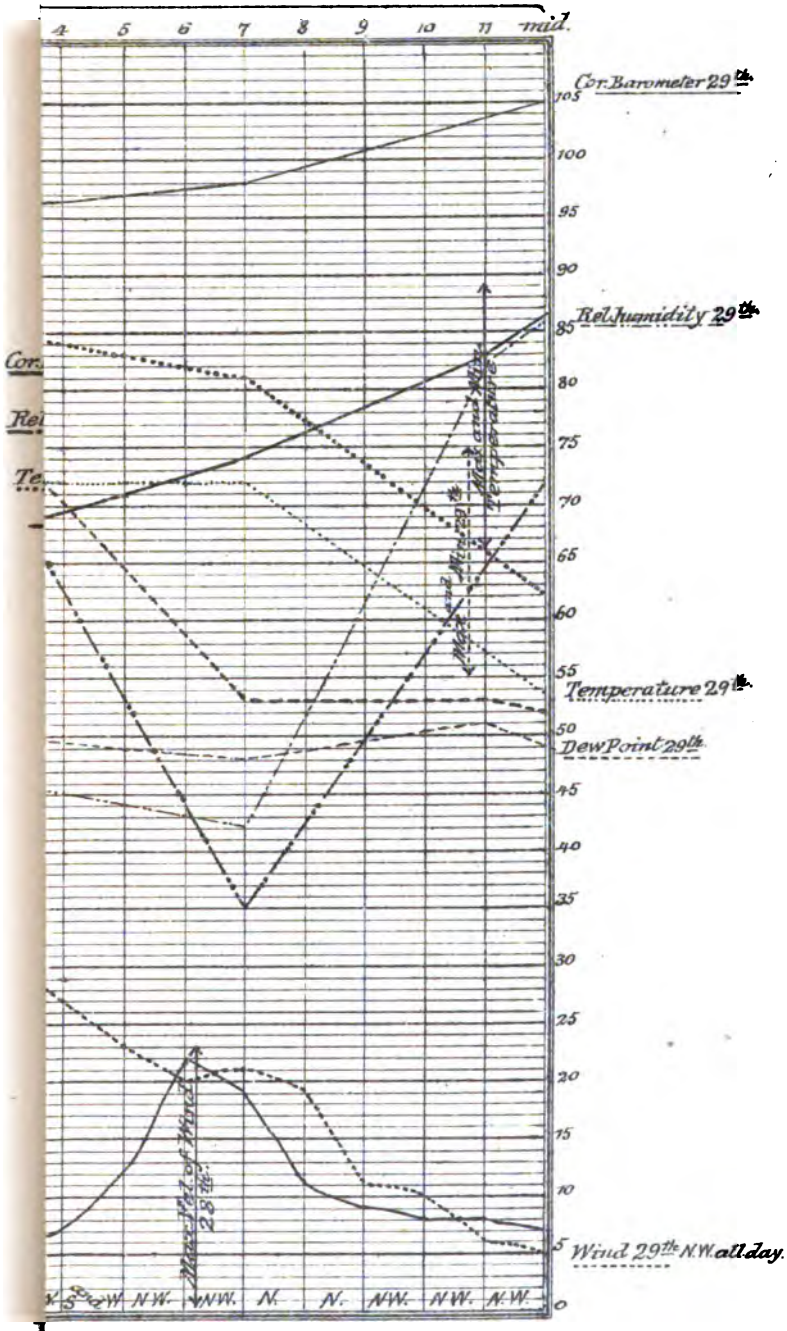
We, the undersigned, hereby certify that we were present in Huron, Dakota, August 28, 1884, and witnessed the tornado which occurred in the afternoon of that day, and that the sketches made by Sgt. S. W. Glenn are, in every particular, true and exact representations of that phenomenon.

JOHN CAIN, *Ed.* "*Times.*"
AUGUSTINE DAVIS,
Ed. "*Huronite.*"
GEO. W. STERLING,
H. of R., 8th Legislative Dist.

} U. S. Signal Service Meteorological Committee, Huron, Dakota.

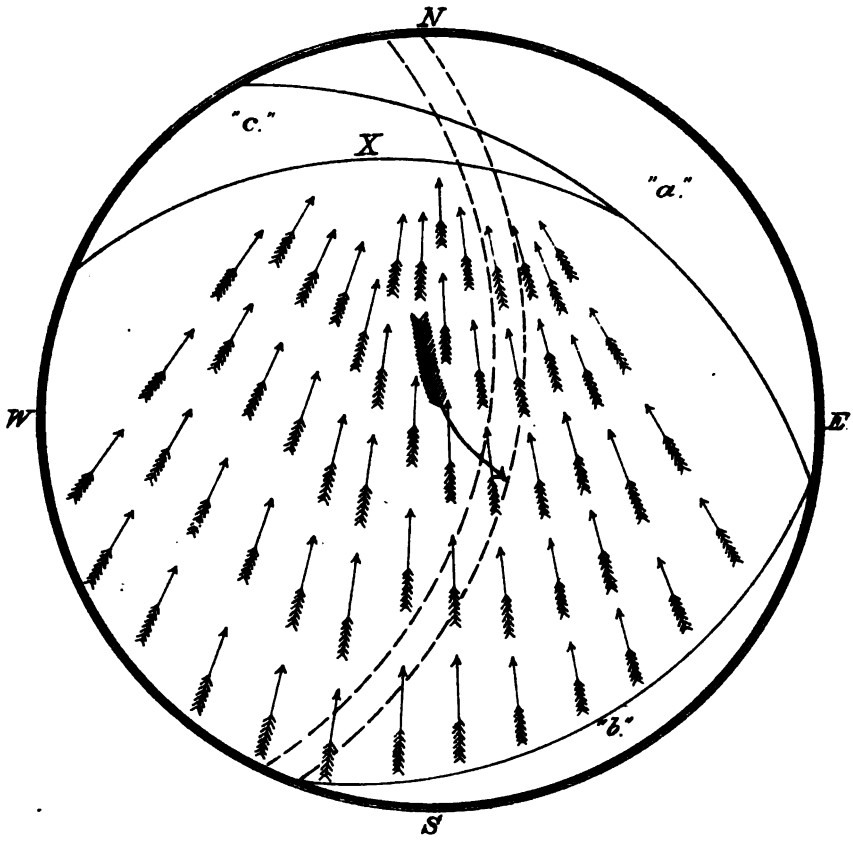
S. C. NASH, Mayor.
J. W. CAMPBELL, President First National Bank.
J. W. SMITH, Cashier First National Bank.
A. J. DICKINSON, M. D., President of Central Dakota Medical Society.
I. J. MOUSER, Register of Deeds and County Clerk.
CHARLES O. MORGAN, Deputy Register of Deeds.

S. H. PLUMMER, Chief Clerk U. S. Land Office.
R. M. HUBBARD, lumber.
F. VOLLRATH, Attorney-at-Law.
H. S. MOUSER, Attorney-at-Law.
THOMAS F. NICHOLL, Civil Engineer.
J. E. ELSON, Police Justice.
BEN. C. WILKINS, Superintendent Western Union Telegraph Company.
L. T. GRAVES, Cashier Ormsby, Graves & Co's Bank.
Rev. A. P. GRAVES, D. D.
D. A. FOOTE, Clerk.
J. A. COLCORD, Merchant.
J. H. DEVOE, Farmer.
A. C. VAN COTT, Bookkeeper First National Bank.
ED. J. MILLER, Assistant Bookkeeper First National Bank.
GEORGE HUNTINGTON, City Treasurer.
O. W. BAIR, City Attorney.
W. H. H. JONES, Insurance Agent.
HAMILTON KERR, Attorney.
C. A. FOWLER, Farmer.
C. D. HOUGHTON, Merchant.
ALVA E. TAYLOR, Attorney and U. S. Commissioner,
LOUIS ADLER, Merchant.
J. K. P. MCCALLUM, Attorney-at-Law.
GEORGE C. KELCHNER, Merchant.
CHARLES REED, Real Estate.
CHARLES ELDRIDGE.
JAMES L. AYRES, Attorney-at-Law.
GEORGE W. MOODY, M. D.
THOMAS A. DUNNING, Merchant.
CHARLES S. DUNNING, Merchant.
JAMES H. PEARSON, Merchant.
ARTHUR E. CARPENTER, Civilian Assistant, U. S. Signal Service.
J. H. GARDNER, Clerk.
CHARLES H. COTTON, Farmer.
HENRY C. HINCKLEY.
W. F. T. BUSHNELL, "Dakota Farmer."
JAMES S. BISHOP, County Superintendent of Schools.
W. W. WOODBURY.
GEORGE J. LOVE, Attorney-at-Law.



Central time.

Fig. 1.



a, *b*. Area of milky-blue stratus cloud, faced with perpendicular streaks of a darker color.

c. Area of white cumulus clouds, rapidly forming into a confused and greatly agitated mass.

Small watery cumulus clouds, all tending to the common centre, *X*, where first indications of a tornado were observed.

Course of the funnel or column which passed near Huron.

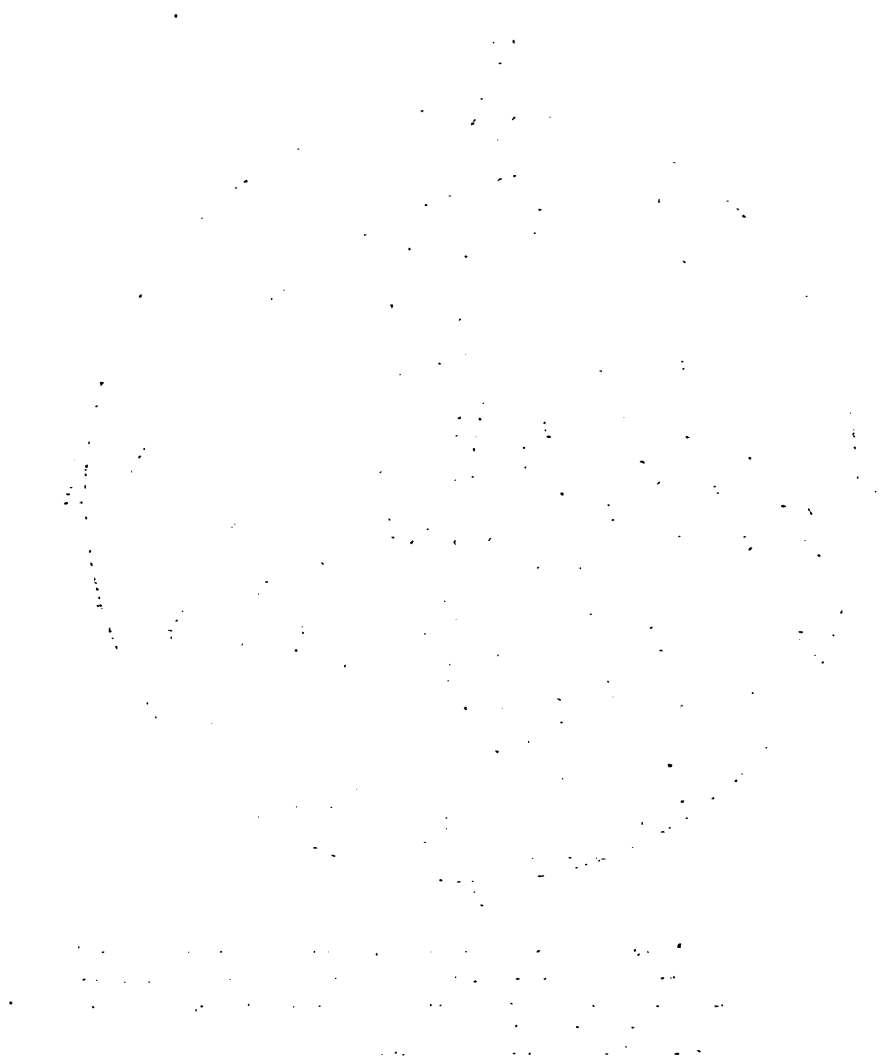
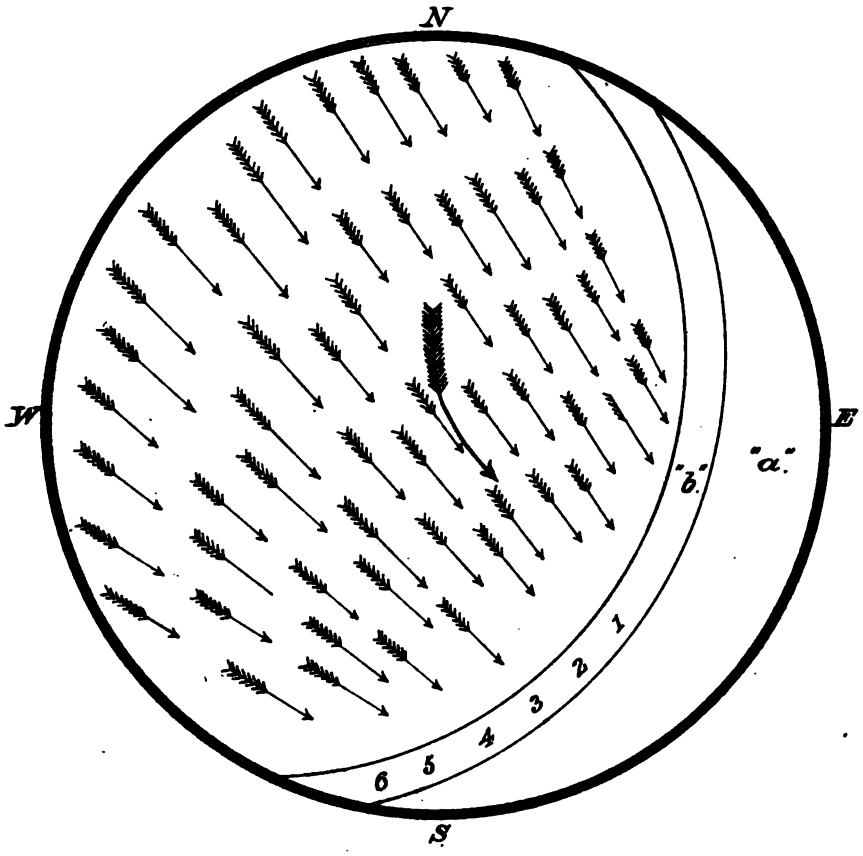


Fig. 2.



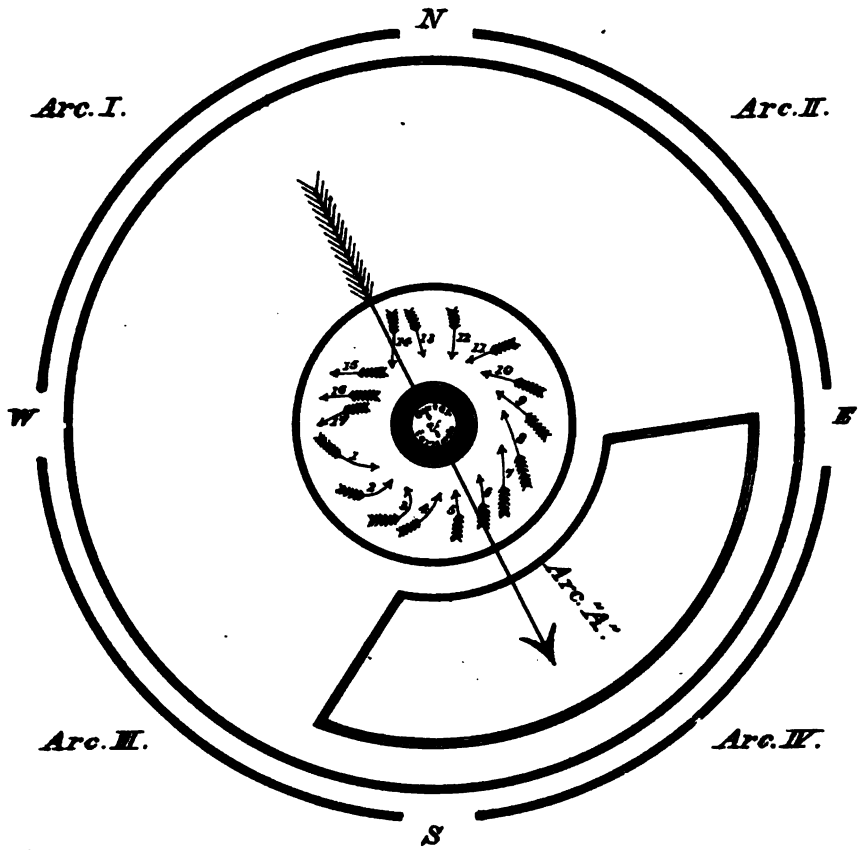
a. Area of heavy stratus or nimbus clouds.

b. Area of cumulus clouds in which were the six funnels or columns shown in sketch V.

Small watery cumulus clouds, apparently supplying area b while it subsided to stratus.

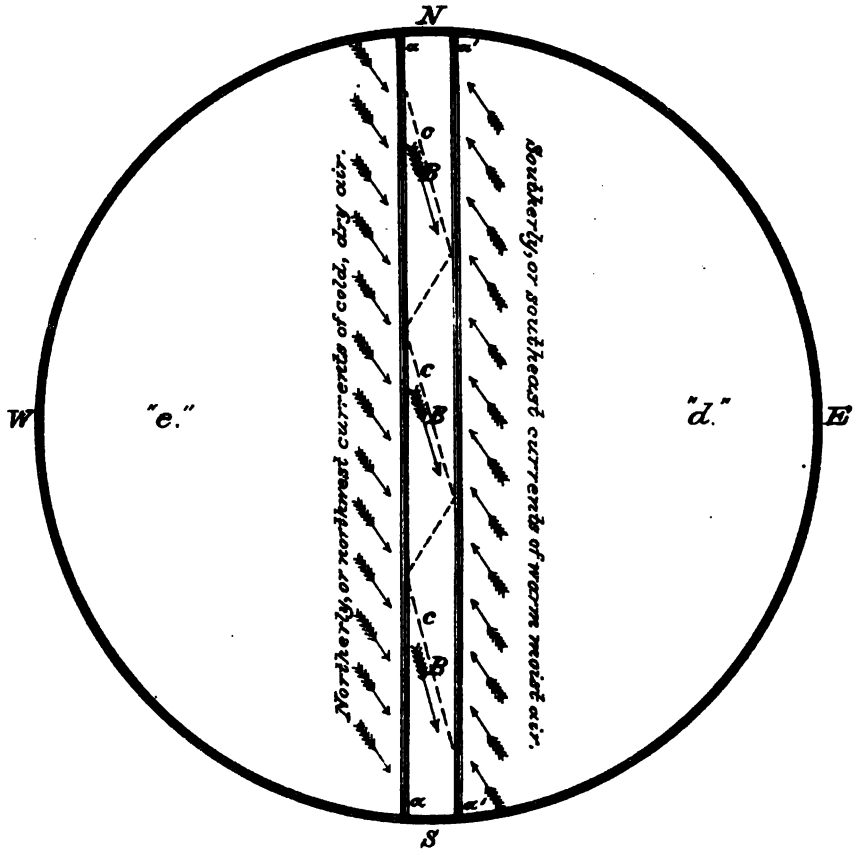
Course of funnel or column which passed near Huron.

Fig. 3.



Large arrow flies with the storm, in its general direction.
Small arrows, 1, 2, 3, 4, 5. Rotary gale, with powerful vertical force at the edge of the funnel or column
Small arrows, 6, 7, 8. Brisk to high steady straight gale.
Small arrows, 9, 10, 11. Fresh to brisk, in gusts.
Small arrows, 12, 13, 14. Brisk to high, increasing as storm-centre passed.
Small arrows, 15, 16, 17. Straight gale of tremendous force, the "sluice-gate," or outlet of all inanimate matter when thrown from the centre of the tornado.
Diameter of inner (destructive) circle, 80 125 yards. Diameter of second circle, 300 to 400 yards. Diameter of outer circle, 2 to 2½ miles.
Arc I. represents fresh to brisk cold northwest winds.
Arc II. represents brisk to high cold north and northeast winds.
Arc III. represents brisk to high warm southwest and south winds.
Arc IV. represents fresh and rapidly decreasing south and southeast winds, warm, moist, sultry, and oppressive; as tornado approached, increasing to gale.
Arc A represents area of comparative *calm*, preceding approach of tornado.

Fig. 4.



a, a, a,' a'. Represents an area of atmospheric conditions probably especially conducive to the formation and uninterrupted progress of tornadoes. Air close and sultry, with light variable winds, and a deficiency of some essential component part of normal atmosphere sufficient to be perceptible to animal life, probably oxygen.

B, B, B. Represents actual track of tornado across the area a, a, a', a', the broken lines beginning where the funnel contracted and left the earth, and ending where the funnel returned to the earth.

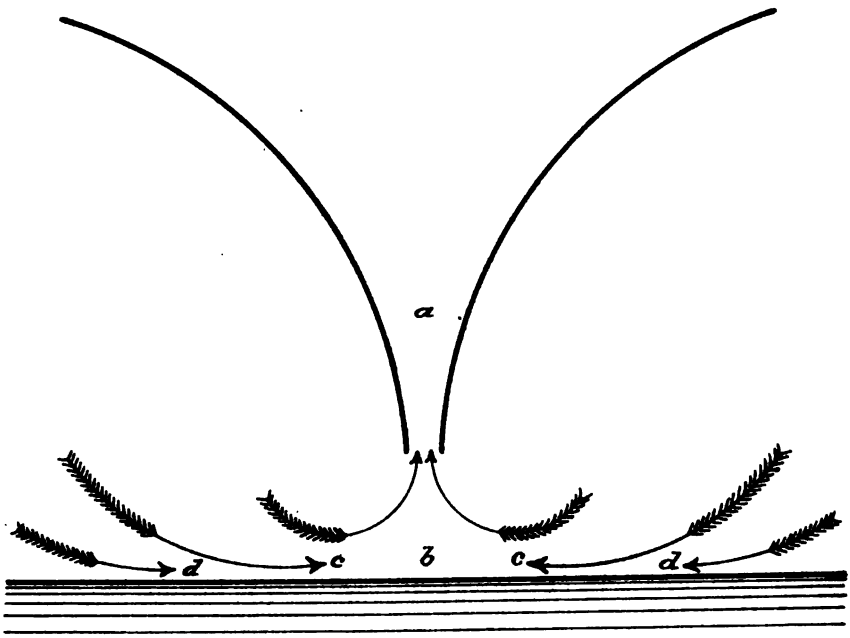
c, c, c. Point of greatest power, when a ribbon-like line of white darted rapidly back and forth from the top to the bottom of the funnel cloud and immediately in the centre of its various curves and vibrations.

d. A possible area of low barometer.

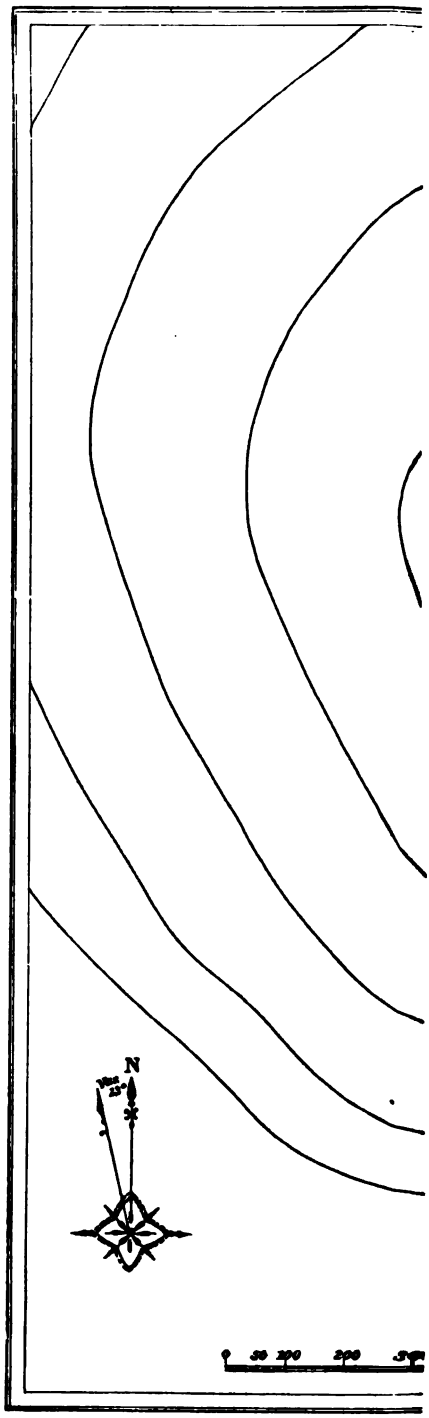
e. A possible area of high barometer.

10 - 6

Fig. 5.



a. Tornado funnel or column..
b. Centre of the vacuum.
c. Point of vertical and horizontal pressure combined.
d. Point of comparative calm or "eddy" caused by currents c and d conflicting with each other.



MAP

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WAR DEPARTMENT.

HARVARD COLLEGE
LIBRARY

SIGNAL SERVICE NOTES NO. XX.

THUNDER-STORMS OF MAY, 1884.

PREPARED UNDER THE DIRECTION OF
BRIG. & BVT. MAJ. GEN'L W. B. HAZEN,
CHIEF SIGNAL OFFICER OF THE ARMY,

BY
H. A. HAZEN,
JUNIOR PROFESSOR, OFFICE OF THE CHIEF SIGNAL OFFICER.

BY AUTHORITY OF THE SECRETARY OF WAR.

WASHINGTON CITY:
SIGNAL OFFICE.
1885.

UNITED STATES OF AMERICA:
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WASHINGTON CITY:
SIGNAL OFFICE.
1885.

1885. June 11

The Signal Office.

NOTE.

The publication of this Signal Service Note is made for the purpose of bringing it to the attention of the public. The Chief Signal Officer does not thereby necessarily endorse the views set forth.

THUNDER-STORMS OF MAY, 1884.

The subject of thunder-storms has attracted much attention of late and a special effort has been made in many foreign countries to collect detailed observations of them. By such observations it is hoped to elucidate the causes underlying their formation, their method of development and their general history. In this country general observations have been made by volunteers under instructions from the Smithsonian Institute as far back as 1849, and by the same with those of the Signal Service since 1871.

These observers have necessarily been far apart and not as uniformly distributed as would be needed for a systematic study of the phenomenon. In January, 1884, the Chief Signal Officer entered into correspondence with the Post Office Department looking to a more uniform distribution of thunder-storm observers through the co-operation of that department.

On March 1, the following card for the detailed observation of such storms, with the accompanying circular (No. 4) of instruction was issued:

[Form 169.]

THUNDER-STORMS.

Data collected by co-operation of Post Office and War Departments.

Town..... *County*.....

State..... *Kind of time used*.....

Date (month and day).....			
Thunder.....	First heard.....		
	Last heard.....		
Direction....	Coming from.....		
	Going towards.....		
Rain.....	Began.....		
	Ended.....		
	Amount.....		
Hail.....	Began.....		
	Ended.....		
	Amount.....		
Wind.....	Before. Dir.....		
	Before. Force.....		
	After... Dir.....		
	After... Force.....		

Distant Lightning.....

.....

.....

.....

.....

Remarks.....

.....

.....

.....

.....*Observer.*

[CIRCULAR No. 4.]

SIGNAL OFFICE,
WAR DEPARTMENT,
Washington, March 1, 1884.

It is desired that during the summer of 1884 a few simple facts be collected relating to the important subject of thunder-storms. To this end post-offices and other centres have been selected, over a limited extent of country, at distances of about forty miles. Each station, it will be readily seen, forms an important point in the network of stations, and by a comparison of these observations it is hoped that valuable acquisitions may be made to our knowledge of these frequent accompaniments of tornadoes. Each thunder-storm should have some note made of it, in order that there may be no gap in any region.

The following instructions are given for guidance in making observations. Each card will have sufficient space for three storms. Give town, county, state, time (whether "mountain," "central," "eastern," or some city), and name of observer.

Thunder-storms twelve hours apart may be taken as separate storms.

Upon the occurrence of thunder give in the appropriate spaces month and day, and, as near as possible, the time of first and and last thunder connected with the storm. Frequently after a storm has passed there will be muttering of thunder, but care should be taken to, as far as may be, watch the single storm.

Give the direction from which the storm appears to be coming, as shown by threatening sky, lightning flashes or thunder peals Also, the direction towards which it goes.

Give time of beginning and ending of rain, with amount, if possible.

If the rain continues rather heavy more than two hours after the loudest thunder has passed, it may be marked "more than two hours."

The amount of rain can be measured, with a common rule, after it has been caught in a pail or empty tomato can with vertical sides.

All observations of hail, size of stones, &c., are very important.

Give directions and force of wind before and after the thunder-storm; for the force adopt the scale of calm, light, moderate, brisk, high, very high, hurricane or tornado.

If you have a thermometer give the shade temperature, or temperature on north side of house, a little before the storm reaches the station as well as after it has passed.

Note, also, if on any day heat-lightning is seen, the date, time of appearance, and direction.

If there is not time for a full report, give date and time of severest part of thunder-storm. Please do not fail to make some note of every distinct thunder-storm that passes over, or within ear-shot of, the station.

Observations should begin immediately upon the receipt of the cards.

This circular is issued with the sanction of the Postmaster General.

If you know some one in your immediate neighborhood who takes an interest in meteorology and would be willing to report, you are at liberty to hand these cards to him.

W. B. HAZEN,
Brig. & Bvt. Maj. Gen'l,
Chief Signal Officer, U. S. A.

These were sent to post offices forty miles apart, from the Atlantic to the 102th meridian west of Greenwich, and from the 35th parallel of latitude to the northern boundary. In Indiana, Illinois, and the circle of one hundred and fifty miles radius, with Washington as its centre, stations have been selected ten miles apart. These cards met with favorable response in a majority of cases, and all records of

hail-storms in May and for thunder-storms on May 18 and 19 have been selected for a special study. Reports of five hundred different storms have been received. From these the following facts have been gleaned. Table I. exhibits a list of all the hail-storms that have been noted.

TABLE I.—*Hail-storms and their relation to "LOW."*

Number.	1884.	Station.	Low. Direction from.	Low. Distance to.	Pressure.	Size, &c., of hailstones.
	Date and hour.			*Miles.*	*Inches.*	
1	April 26, 8 p. m	Concordia, Mo	se.	240	29.4	Pigeon's eggs.
2	29, 5 p. m	Montevideo, Minn	e.	200	29.6	Slight.
3	May 3, 7.10 p. m	Franklin, Ind	ne.	900	30.1	
4	4, 2 p. m	Rockport, Dak	e.	100	29.6	Small.
5	5, 3.30 p. m	Troy, Mo	s.	100	29.6	Large as hen's eggs.
6	6, 8 p. m	Dayton, Ohio	e.	50	29.8	8–14 inches deep.
7	8, 8 p. m	Rothrockville, Pa	se.	125	29.9	Heavy.
8	9, 1.40 p. m	Ludlow, Pa	s.	120	29.8	Small.
9	10, 7.15 p. m	Mooresville, Ind	se.	240	29.8	Large as peas.
10	11, 9.58 a m	Lyons, N. Y	sw.	40	29.6	Large as buckshot.
11	11, 2 p. m	Statesville, N. C	*	*	29.75	.3″ deep.
12	11, 3.15 p. m	Cowpens, S. C	*	*	29.75	Large as partridge eggs.
13	12, 6 p. m	Ft. Madison, Iowa		0	29.75	3″ circumference.
14	16, 1.10 p. m	Ogallah, Kans	e.	100	29.8	
15	17, 5 p. m	Fall River, Mass	s.	125	29.7	Good size.
16	17, 5 p. m	Providence, R. I	s.	125	29.7	
17	18, 4 a. m	Murphysboro, Ill	s.	300	29.7	Small.
18	18, 2.30 p m	Waverly, Ill	s.	300	29.7	
19	18, 7.30 p. m	Worthington, Ind	se.	270	29.7	
20	19, 12 20 p. m	Vevay, Ind	s.	360	29.6	Size of buckshot.
21	19, 12.20 p. m	Westerville, Ohio	se.	300	29.5	.5″ in diameter.
22	19, 2.10 p. m	Cheshire, Ohio	se.	350	29.6	
23	19, 6.30 p. m	Statesville, N. C	s.	000	29.8	
24	19, 7.15 p. m	Marion, Va	e.	580	29.8	.5″ in diameter.
25	19, 8.30 p. m	Sandy Spring, Md	se.	500	29.8	
26	20, 8.45 p. m	Sherlock, Kans	e.	50	29.6	Light.
27	21, 12.05 a. m	Cleburne, Tex	se.	500	29.9	
28	21, 3.30 p. m	Allison, Kans	e.	100	29.6	
29	21, 8.15 p. m	Maple Grove, Va	s.	300	29 9	Broke windows, &c.
30	22, 2.05 p. m	Humboldt, Iowa	s.	50	29.7	
31	22, 4 p. m	Sussex, Wis	se.	150	29.7	
32	22, 4 p. m	Northfield, Minn		0	29.7	
33	25, 1 p. m	Brevard, N. C	e.	†	30.0	
34	26, noon	Noblesville, Ind	e.	*	30.0	Slight.
35	26, 10.20 a. m	Rising Sun, Ind	e.	*	30.0	
36	26, 2.40 p. m	Frankfort, Ind	e.	*	30.0	Considerable.
37	26, 2.40 p. m	Stockwell, Ind	e.	*	30.0	
38	27, 2 p. m	Fort Wayne, Ind	e.	*	30.0	
39	27, 7.10 p. m	Chambersburg, Pa	ne.	*	30.0	Size of peas.
40	27, 7.40 p. m	Wytheville, Va	s.	*	30.0	
41	29, 4 p. m	Sherlock, Kans	ne.	300	29.9	
Mean, omitting indefinite			se.	238	29.72	
Mean of all					29.78	

* Not well marked. † Atlantic.

Ten of the falls occurred when no well-defined LOW was present; the remaining thirty-one occurred in a direction southeast from LOW and at a mean distance of about two hundred and forty miles, with a mean pressure of 29.72 inches. These facts show the prevalence of hail-falls near LOW, and ordinarily with a pressure considerably below the mean.

THUNDER-STORMS OF MAY 18TH AND 19TH.

It was found that the 16th ushered in a system of thunder-storms of great extent and intensity, culminating on the 18th and 19th. Charts A and B have been prepared showing in full black lines the progress of the thunder-storm action for each four hours, beginning with 4 a. m. of the 18th and with 8 a. m. of the 19th. There

is also shown upon each map, by a dotted line, the position and track of the LOW accompanying the storms. The figures 18-1, 18-2, 18-3, &c., on this dotted line show the position of LOW at 7 a. m., 3 p. m., and 11 p. m., respectively.

This LOW was central in Colorado on the 16th, and advanced in an east-northeast direction at a rate of 15.3 miles per hour, or much less than the average May velocity, which has been 25.7 miles per hour for the eight years 1876–1883. Table II. shows the average velocity of LOW for intervals of eight hours on the 18th and 19th:

TABLE II.

Interval.	Velocity.
18-1 to 18-2	32
18-2 to 18-3	21
18-3 to 19-1	18
19-1 to 19-2	27
19-2 to 19-3	7
19-3 to 20-1	21
Mean	21.0

The first thunder-storms accompanying this LOW are reported from Kansas morning and afternoon of the 16th. No storms of importance are reported on the 17th. On the 18th they were general in Illinois and Indiana. On the 19th the region of general action had advanced markedly to the east. Beginning with storms in Indiana in the morning, we find them spreading out like a fan from this region to the southeast and east (see chart B). The extreme eastern limit of these storms of the 19th was Mountainville, New York, where there was no thunder but distant lightning was seen in the southwest. The gradual advance of the storms from west to east and southeast is plainly indicated on maps A and B, by following the lines of general action at each four hours. The average distance apart of these lines on chart B gives in Table III. the velocity of the thunder-storm action during each four hour interval.

TABLE III.

Interval.	Velocity.
8 h. to noon.	52
Noon to 16 h.	49
16 h. to 20 h.	33
20 h. to midnight.	29
Mean	41

This great velocity of thunder-storms above that of the accompanying LOW, amounting in this case to more than double on the 19th, is very interesting and demands further investigation. Are thunder-storms in a measure entirely outside of the influence governing low, or are they at such a great distance from the LOW as to attain a greater velocity going upon a large circumference rather than upon a straight line? The rapid dying out of this action in the later hours of the day, and its starting up again the next morning are also noticeable features.

On comparing the distances of these storms we find the average to be about four hundred and fifty miles from LOW, and the direction southeast.

CONCLUSIONS.

1st. Hail-falls occur ordinarily with pressure much below the normal to the southeast of LOW, and at a distance from it of two hundred to three hundred miles.

2d. Thunder-storms advance from the west toward the east and southeast, generally accompanying a LOW, and in the southeast quadrant at a distance of four hundred to five hundred miles.

3d. The action seems to die down at night and begin again in the morning, and often spreads in a fan shape to southeast and east.

4th. The velocity of the thunder-storms is greater than that of the accompanying LOW.

These preliminary deductions are here made simply as showing, what may be hoped for from a critical examination of reports at stations near each other.

H. A. HAZEN,
Junior Professor,
Office of the Chief Signal Officer.

June 6, 1884.

NOTES.

The following notes are added here in partial extension and explanation of the circular on page 4:

The necessity of placing the town or post office address upon each card will be very apparent, many cards had been received which have lost much of their value because of this omission. It is desired that the post office address be first entered and next the town, if the two do not coincide, *e. g.*, Albany (Menand Station).

The subject of the kind of time used has caused some confusion. In November, 1883, most of the railroads adopted a system of reckoning time which is very convenient and does away with most of the seventy or more previous standards. Four standards are used, which may be designated as Eastern, Central, Mountain, and Pacific. The central meridian for each of these is, for the 1st, 75°; 2d, 90°; 3d, 105°, and 4th, 120°, all west of Greenwich. Eastern time is used by railroads and most towns lying between longitudes 67½° and 82½°; Central time is used between 82½° and 97½°, &c. The simplest method of getting time would be from the nearest railroad, and in such case the only record needed, for "kind of time used," is the name of the railroad furnishing it. If, however, it is found impossible to obtain railroad time, then the kind of time used should be noted thus: "Columbus, Ohio, time," "sundial time," &c.

It is important that in all cases the morning and afternoon records be clearly distinguished. The most convenient method of doing this, and one already adopted by many observers, is to divide the day into twenty-four hours, beginning with 0 hour, or midnight of the previous day, and counting to midnight. By this method 7.15 would indicate a morning observation at 7 o'clock and 15 minutes; 23.15 a night observation at 11 o'clock and 15 minutes. The morning hours would be written as at present, but the afternoon hours would have twelve added to each. If this system is not used care should be taken to place the needed a. m. or p. m. after the figure denoting the time.

In addition to the record called for on the card, it is desired, if possible, to introduce a scale for thunder-storm action, in order to make future comparisons more satisfactory. The following scale is suggested:

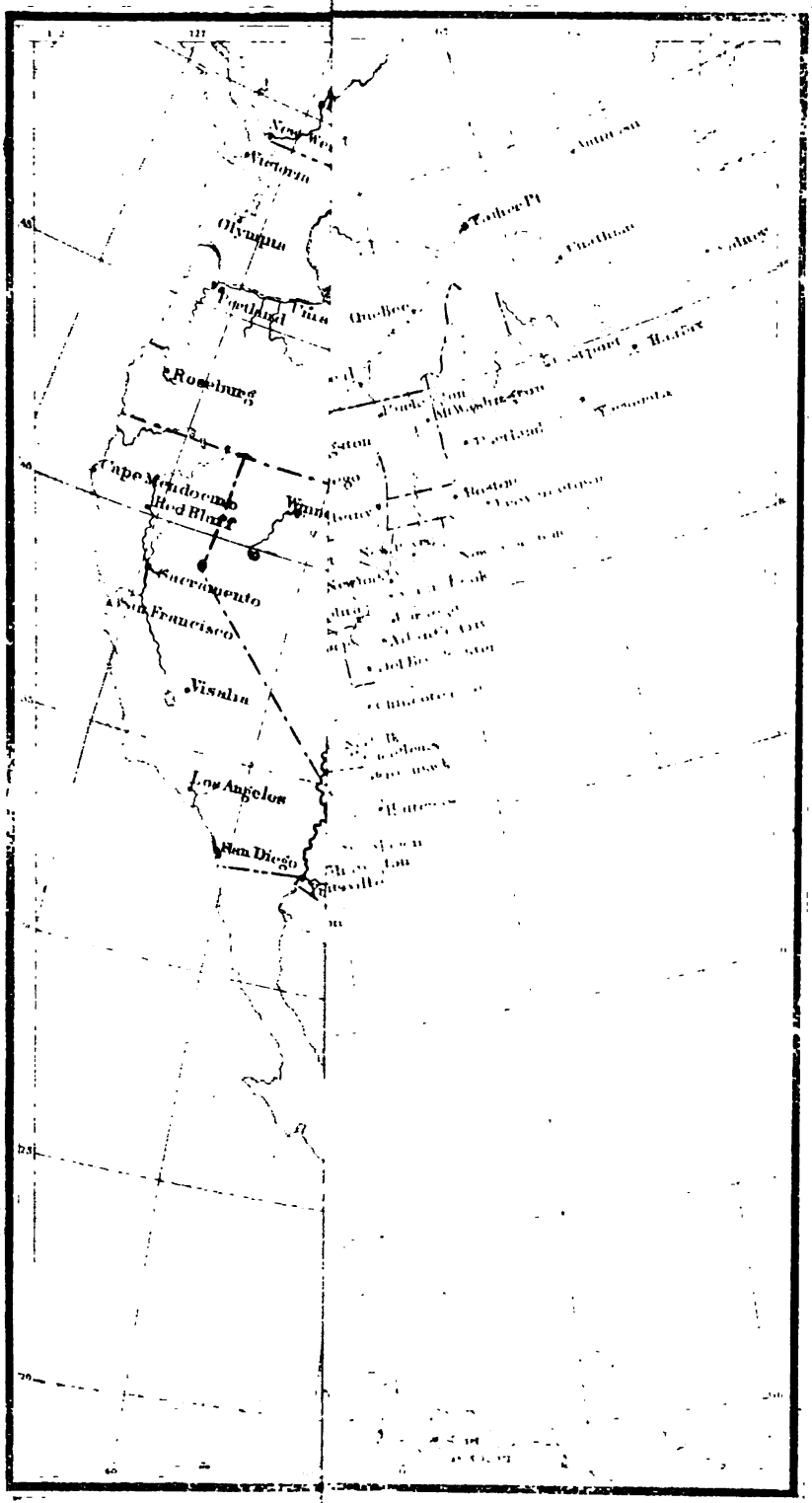
1. Distant lightning.
2. Distant thunder.
3. Moderate thunder-storm.

4. Heavy thunder-storm.
5. Heavy thunder-storm, with very high wind, uprooting trees, blowing down buildings, &c.

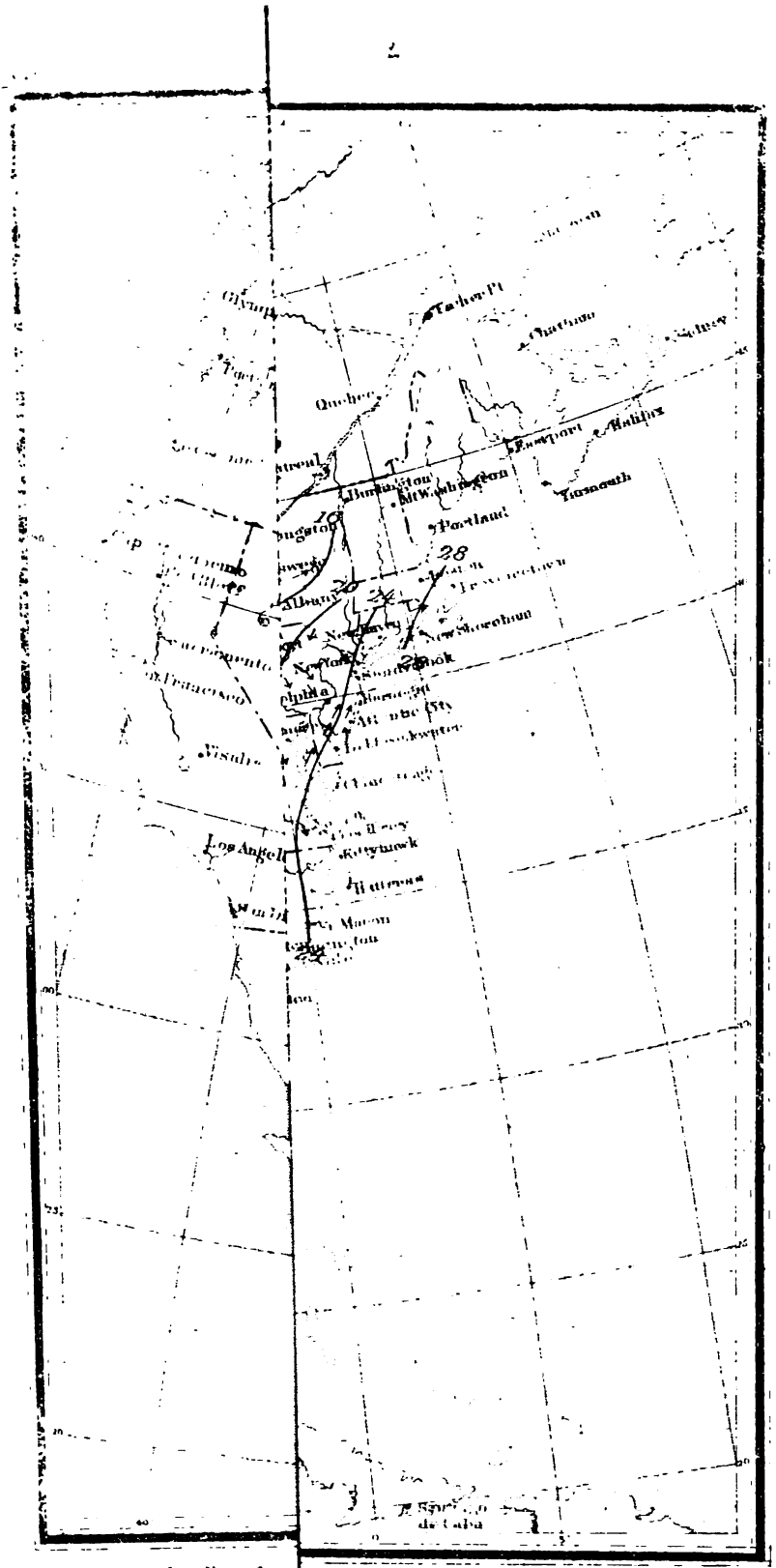
It is desired that each card be mailed as soon as filled. When there are only two cards left, make note to that effect on the card sent in.

It is not necessary that an observer remain in any one place for all his records, but every thunder-storm should be recorded wherever experienced. Observers are desired in towns where there are none now. Necessary instructions and postal cards will be sent any person who applies to the Chief Signal Officer of the Army.

Form 106 F.



Full curves show lines of general act[illegible]8th, 7 a. m.); 18–2 (18th, 3 p. m.); 18–3 (18th, 3 p. m.), &c.


Portland
Albany
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Full curves show lines of gen

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